

# The Chemical Age

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## The British Chemical Plant Exhibition

THOSE who were present at the opening of the British Chemical Plant Exhibition, and the subsequent inaugural luncheon on Monday, must have carried away with them "thoughts that are the seed of action." The manufacturing chemist must have perceived, not (we hope) for the first time, the debt he owes to the maker of plant; the plant maker will realise how great a work it is that he does for chemical industry, and that realisation will ennoble all those seemingly useless hours when, like a commercial traveller, he occupies time in selling plant that he would much rather, and apparently more profitably, employ in design, in research and in manufacture.

More than one eminent speaker was of the opinion that the most remarkable feature of modern industrial life is the continual search for new products—a search to which attention has frequently been called in these pages. This search is dictated by necessity. The demand for a natural product shows signs of outstripping the ability of nature—even of fertilised nature—to fulfil, immediately research is set on foot to manufacture a substitute, or a "synthetic" product. The prodigal hand of the manufacturer and consumer denudes the earth of minerals which industry needs; and immediately research finds an alternative. The natural material may be too expensive; research manufactures a synthetic article that may be as good as or better than the original product, and at a tithe of the cost. In this way we have found and manufactured synthetic ammonia, synthetic rubber, artificial silk, synthetic oils (diesel and petrol), plastics, and a host of medicinal preparations that has relegated the old herbalist to something not far removed from charlatanism, in the belief of many who but for the discoveries of chemistry would even now be his customers. The terms "artificial" and "synthetic" have ceased to be used in reproach, but have come to denote but another victory of science—an excellent point stressed by the Duke of Kent in opening the Congress. We are in truth at the dawn of a new age—the age of conversation of resources which will be brought to pass primarily through synthesis of the rare from the plentiful.

This is not all. Lord Leverhulme rightly drew attention to the fact that only within the last few years has the harmful effect of the plant on the product received attention. Corrosion has become a subject of the first importance, and apart altogether from its importance in manufacturing costs, its bearing on the contamination of the products has been recognised. The plant maker has assisted in a vital manner to meet this new situation by the provision of new alloys

and by the discovery of methods of constructing reliable plant from these materials. The continued search for new products has resulted in the demand of the chemist for methods involving manufacture at high pressures, and not infrequently at high temperatures also.

Lord Leverhulme asked that the coming generation of chemical engineers should be made "pressure-minded," the provision of vessels to withstand these pressures is the province of the plant maker. The chemist in his laboratory discovers the new materials of which we have written. The consumer desires to use them. Between the two stands the chemical engineer who, as manufacturer must translate these processes onto the works scale, and as plant maker must solve the numerous problems involved in constructing plant that shall enable the large-scale reactions to be conducted without danger, without undue cost, and without contamination of the product. In Dr. Stine's words, "the ability to produce has often waited on new equipment." The engineer sooner or later collides with the limitations of his material, and every new chemical made introduces new problems in plant design.

The British Chemical Plant Exhibition shows to some extent what British plant makers can do. No better reference was made to the exhibits, and to the industry generally, than the recall by Dr. Bush of Mr. Ramsay MacDonald's own words when opening the Billingham hydrogenation plant: "There is no slapdash here; no assumption of conclusions; care and efficiency are the conditions of enduring work." Twenty years ago there was virtually no British chemical plant industry. Those who have examined the exhibits can best judge the tremendous advances made.

But let there be no mistake about it. This exhibition is really in the same relation to the British chemical plant industry as a single pound sample of tea is to the varied bulk stocks carried by a tea warehouseman. There is nothing more difficult to put on a show stand than chemical plant. It is impossible to make plant specially for an exhibition unless one is making regular lines for stock. Buyers do not usually wish the plant they have ordered to be shown publicly. Some firms well able to carry out immense jobs did not take space because they had nothing suitable for showing. For instance, it was not possible to show a gasholder, a cement kiln, or a synthetic methanol plant. Only the small, and to some extent the more commonplace goods could be shown; but those that were shown, demonstrated the high quality of British workmanship. Unquestionably the B.C.P.M.A. is to

be warmly congratulated upon the success of the exhibition and it is to be hoped that all firms that make chemical plant, whether they exhibited or not, will join the Association.

The chemical manufacturer too, can learn a lesson from the opening speeches at the exhibition. No reputable plant manufacturer has ever, so far as the Association knows, betrayed a confidence. If chemical manufacturers would take the plant makers more into

their councils when there are problems to be faced, they would have at their disposal a wealth of technical information and skill that has in many instances been gained over a wide international field and in investigating the problems of many industries. Mr. Russell, from his wide experience asked that user and manufacturer should discuss details with the utmost frankness and should make joint preliminary tests. Every chemical engineer of experience must endorse that plea.

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## Notes and Comments

### Royalty and Chemical Engineering

THE Duke of Kent rendered signal service to the cause of international chemical engineering by granting his patronage to the Chemical Engineering Congress and by opening the proceedings at Westminster on Monday afternoon. Not only did he honour the home and overseas delegates by welcoming them in person, but he revealed an intimate interest in the work of the chemical engineer by recalling visits which he had paid to various industrial establishments during his close association with the Home Office, in the course of which he witnessed chemical reactions carried out on a large scale under precise control and under conditions of the utmost safety for the worker. It was fitting that just twelve years after his brother, the King (then Prince of Wales) opened the first World Power Conference at Wembley, the Duke should perform a similar function at the Chemical Engineering Congress, which is being held under the auspices of the same parent organisation. It may be many years before a similar gathering is held in this country, but we are certain that every one of the members who heard the Duke's speech on Monday will carry home an indelible impression of the real personal interest which the members of our Royal Family take in scientific achievement and the progress of industry.

### Origin of the Congress

THE idea of holding the Chemical Engineering Congress in London did not, as many people have imagined, originate with the World Power Conference, but was due to the initiative of the late Sir Frederic Nathan, whose many friends deeply regretted that he was not spared to see his hopes realised. It had long been felt that it was time for chemical engineers in various countries to review their progress and to consolidate their achievements and it was from this fact that the conception of an international congress gradually emerged in this country. If the World Power Conference had not existed it would have been necessary for the promoters of the congress to create their own machinery for the promotion of participation from overseas, with a result which might well have fallen short of what has actually been achieved this week. The International Executive Council and the National Committees of the World Power Conference, however, brought their ripe experience to bear upon organising the congress and the results have been eminently satisfactory not only from the point of view of numbers but from the standpoint of active participation and the presentation of papers. It must

not be implied, however, that the association of the Congress with the World Power Conference is fortuitous. The main purpose of the World Power Conference is to bring together those directly concerned with the power and fuel industries in each country in order to ensure that their problems are considered from an international as well as national standpoint, and there is certainly no more vital contribution to be made to the solution of those problems than that provided by the chemical engineer.

### Birthday Honours

IT was singularly appropriate that the first birthday honours list in the reign of King Edward VIII should have included the names of so many members of the chemical industry and profession and that it should have been issued at the time when over 600 chemical engineers from all parts of the world were assembled in London for their first international congress. The chemical profession will surely rejoice in the fact that Professor G. T. Morgan has received a knighthood. Apart from his valuable work at the Chemical Research Laboratory at Teddington during the past eleven years, he has served the interests of chemistry in a variety of ways and has occupied the presidential chairs of both the Chemical Society and the Society of Chemical Industry. Another well merited distinction is the knighthood conferred upon Dr. James Morton for his services to the dye and colour industries. In a different sphere—that of public service—there are Alderman Harry Speakman, of Leigh, Lancashire, and Mr. Frederick J. West, of Manchester. Other names which appear in the list have interests of pharmaceutical, physical testing and public health nature, whilst three recipients reflect the chemical activities of the Admiralty, War Office, and Royal Arsenal. It is certainly good to know that the scientific side of the industry is thus recognised in high places, but we feel that an undue proportion of these science honours have been bestowed for work which seems to have been more intimately connected with warlike preparations rather than peace-time activities. The chemical-using industries to-day have a very wide connection with national progress, and there must be much work which has fully justified recognition, but has remained unrewarded. Reviewing our knowledge of the progress of chemical science during the past few years—aye, many years back into the reign of King George V—it cannot be overlooked that chemistry, and especially biochemistry, has contributed much towards the health of the people of this nation and of the world generally.



# British Chemical Plant Exhibition

## Mr. Ramsay MacDonald performs the Opening Ceremony

**M**R. J. RAMSAY MACDONALD, Lord President of the Council, opened the British Chemical Plant Exhibition at the Central Hall, Westminster, on Monday morning in the presence of a large number of members of the Chemical Engineering Congress of the World Power Conference, which is being held in the same building. Immediately before the ceremony Mr. MacDonald received Lord Leverhulme, president of the Congress, Sir David Milne-Watson, chairman of the organising committee of the Congress, Sir Harold Hartley, chairman of the World Power Conference, Sir Frank Smith, secretary of the Department of Scientific and Industrial Research, and the members of the executive committee of the British Chemical Plant Manufacturers' Association. Among those on the platform were the principal representatives of overseas countries attending the Congress.

Mr. J. H. G. MONYPENNY, chairman of the British Chemical Plant Manufacturers' Association, who presided at the ceremony, expressed a special welcome to the overseas visitors. The first British chemical plant exhibition, he said, was held in 1926 when the Congress of Chemists met in London. The display was a

modest one and limited to the basement hall of the Central Hall, but it certainly fulfilled its object of demonstrating to the hundreds of chemists attending the congress that British industry had made great progress during the post war years in the design and construction of chemical plant of all kinds. Stimulated by the success of this initial venture, the Association decided to organise periodic exhibitions whenever similar opportunities occurred. It had to wait five years, but it was well worth while, for the next occasion

was the jubilee celebrations of the Society of Chemical Industry in 1931, and at that exhibition they filled both the ground floor and the basement hall. They had also the good fortune to secure the co-operation of the Department of Scientific and Industrial Research which, in conjunction with the Chemical Engineering Group of the Society of Chemical Industry, organised in one of the small halls a co-operative exhibit from the industrial research associations operating under the aegis of the Department. They were so satisfied with the results that they decided to hold these exhibitions regularly, at a suggested interval of three years. They arranged with their French and German friends in the chemical plant industry, who also held similar exhibitions, that they should have a regular rota, so that only one exhibition should be held each year. The three-year proposal had been upset by the depression which had affected them all, but they had still been able to hold to their original plan of avoiding two exhibitions in one year.

When it was decided to hold the first international Chemical Engineering Congress in this country this year under the aegis of the World Power Conference, they felt it was a unique opportunity for the exhibition, even though it meant an interval of five years since the last display. Thanks were due to the Congress authorities for the way they had co-operated in all their plant, and he felt sure that both the exhibition and the congress would benefit from the present arrangements. He also hoped that the foreign visitors would be equally grate-

ful for the facilities afforded to them by having both functions in such a handy juxtaposition.

The exhibition had filled all the available space, and they could have utilised a great deal more. This indicated the great interest that the British chemical plant industry had taken in the exhibition, and showed how it appreciated the unique opportunity afforded by the Congress of displaying its wares to chemists and chemical engineers from all over the world.

They were fortunate in having the co-operation of the Department of Scientific and Industrial Research in the organisation of an exhibit to show the benefits of scientific research in industry, with special reference to chemical engineering. While limitations of space had seriously curtailed the extent of the display, the Department, with the help of its research stations and the industrial research associations, had been able to illustrate the wide diversity and the high standard of research work which was going on in this country and on which the future progress and prosperity of so many British industries depended. They were grateful to the

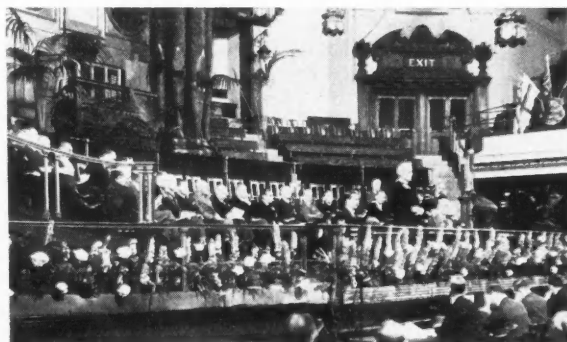
Department for all it had done to enhance the value of the exhibition, and they were honoured by the fact that the political head of the Department, Mr. Ramsay MacDonald, Lord President of the Council, had consented to open the exhibition.

The exhibition bore evidence of the great progress made during the last few years in the design and construction of chemical plant of all kinds, and in the materials of which they were made. What the exhibitors were showing represented only a small part of what they were doing or are

able to do. With few exceptions they could produce all the plant and equipment required by every industry in which chemical engineering was employed, and the plant was of that high quality and efficiency which the whole world had learned to expect from British engineering. That claim extended not merely to the chemical and closely allied industries, but also to a large number of diverse industrial activities outside what was generally regarded as the chemical field, such as those connected with artificial silk, brewing, dairying, sugar, soap, petroleum, fumigation, dry cleaning and laundering, to mention only a few. Everything was British and the standard set was purposely high. To qualify as British they had demanded that at least 75 per cent. of the cost of production of the article must represent British (which included Empire) labour, and/or materials. For the British Industries Fair there was a much less stringent requirement for a minimum of 51 per cent.

### A Plea for Co-operation

There were a few things they did not make at present, but they claimed they were able to make them provided the purchaser would come to them and disclose the full details of his requirements. They would respect his confidence, and would put all their cards on the table if he would do likewise; they felt certain that the outcome of such co-operation would be to the advantage of both parties. If matters could be discussed on a basis of mutual confidence and understanding, the maker



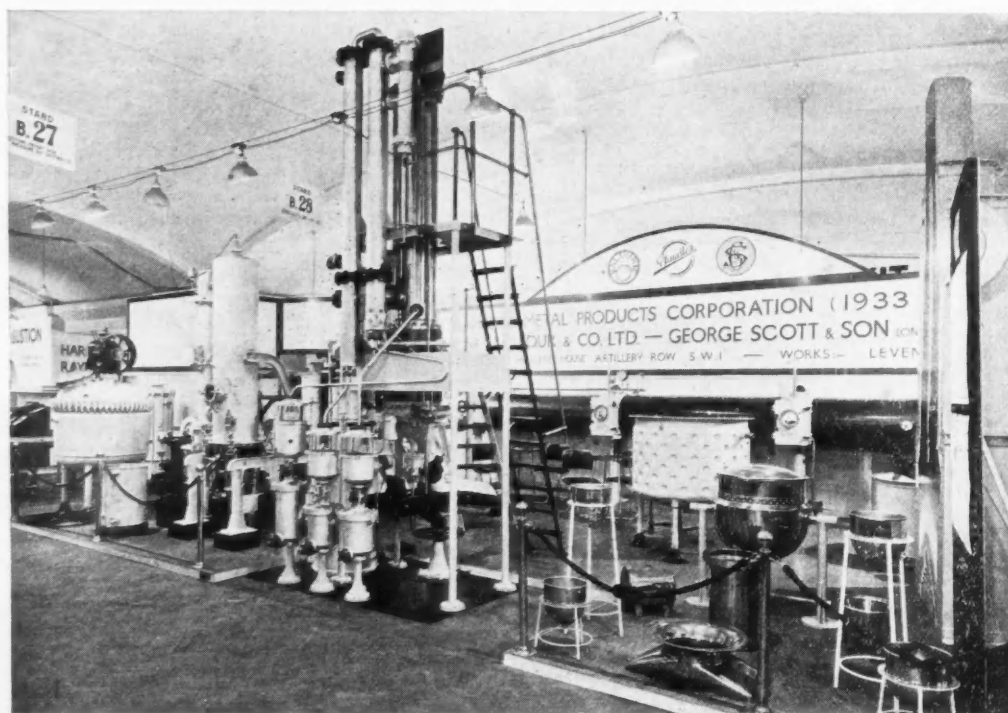
An impression of the opening ceremony at the Central Hall, Westminster, on Monday morning.

of British chemical plant was convinced that he could satisfy the needs of the user as well as, if not better than, his most efficient foreign competitors.

Mr. RAMSAY MACDONALD, in opening the exhibition, said he was profoundly convinced that the next phase of our industrial revolution would be based largely—certainly to a greater extent than ever before—upon the application of science to industry. In a rough sort of way that had always been true, but the realm of science was extending and deepening. As the result of experiments in the laboratory processes were being made available for application on a large industrial scale in ways that had never before been possible.

The very fact that the Privy Council had become associated, not exactly as originator, but as a kind of foster mother, with the work of scientific and industrial research meant that the

invested capital to maintain the economic fabric of the State. A year or two ago had they met casually and begun to discuss oil from coal, how long would they have imagined it was going to take to obtain it? To-day it was here—pure spirit from the clinging dross. It was no longer a dream, a phrase, an imagination of the philosopher, but a hard practical achievement of the scientific mind. Artificial silk was another great new creation for which scientific men were responsible, and again they had taken their material from sources which might naturally have been discarded by people of unpenetrating minds. There was also the question of the soil. Every nation in the world was beginning to see that the greatest problem was to get the people back on to the soil. They were not going to cultivate great races of people with personality and genius and power under glass. They had to



The stand occupied jointly by the Enamelled Metal Products Corporation (1933), Ltd., Henry Balfour and Co., Ltd., and George Scott and Son (London), Ltd., provided a most unusual display of chemical plant, which reflected many innovations in recent chemical engineering progress.

chemist and the physicist, and the engineer co-operating with them both, had to produce plants that were practicable. They were going to have no shoddy things if they were to receive the assistance for which they could properly ask from the whole resources of the community. With new plant, new methods and new technique the years that were to come would yield stories in the evolution of our history just as conspicuous, as wonderful, and as miraculous as the history that was written when steam first of all began to be applied and engines manufactured.

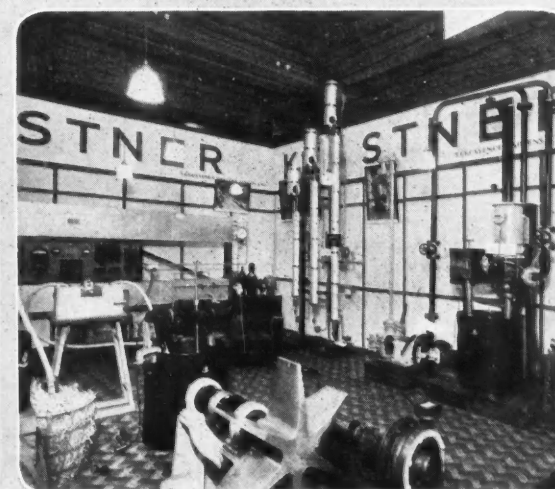
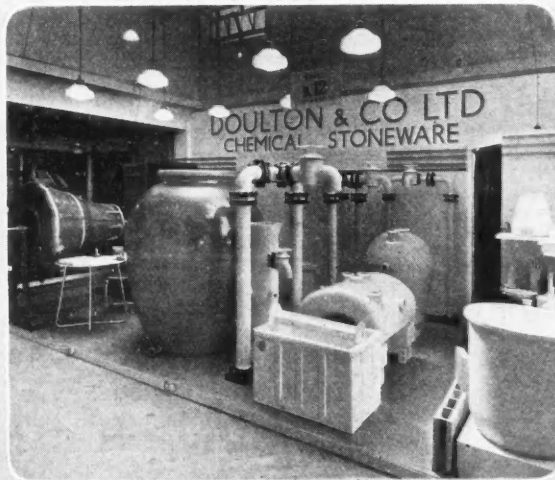
We were on the threshold of an era of power, and the application of power that gave great promise for the industrial, engineering and scientific future of this country. At Billingham and elsewhere he had seen British engineering in the plentitude of its power, not finished, not exhausted, but a promising and lusty youth. Two features for which some of them had always looked were economy of power and the best and most ingenious design that could be created, and both of these were to be found in the present exhibition.

The enterprise of the chemical engineer ranged over a field of the greatest and most fascinating interest, a field of the widest importance, a field upon the proper scientific cultivation of which depended the future of hundreds of thousands of workers in this country and millions and millions of

put them into the fields to enable them to raise their heads high in the air, and the only way was to make the soil fertile under labour. Whilst they were playing with the reduction of coal into spirit and the creation of silk, they were also dealing with those elements which must enter into the composition of the soil and the production of the one blade of grass where none grew before.

It would be a bad day when science divided itself into camps hostile to each other. The beneficent work of the scientist must be continued along co-operative lines or that great power that was coming upon us was going to be turned to mutual destruction. What a terrible denial would be made by man of the beneficent forces of creation with which he was only new coming into close understanding. He hoped all who had come to the exhibition and the Chemical Engineering Congress would go home more determined than ever that their discoveries, their aims and achievements, their successes were all meant to be woven into one great service to be laid at the foot of humanity itself.

Dr. H. J. BUSH, proposing a vote of thanks to Mr. Ramsay MacDonald, said the Lord President did not come amongst them as a complete stranger to chemical engineering and plant manufacture. A short while ago he opened the extensions to the Paint Research Station, and showed himself on that



Six of the outstanding features of the British Chemical Plant Exhibition: A display of control instruments by George Kent, Ltd.; chemical stoneware by Doulton and Co. Ltd., and Hathernware Ltd.; the stand occupied by THE CHEMICAL AGE; aluminium, copper, nickel and stainless steel plant by The Aluminium Plant and Vessel Co. Ltd.; and part of the exhibits of The Kestner Evaporator and Engineering Co. Ltd.



occasion fully alive to the many and varied questions that confronted the chemical plant manufacturer who supplied the wants of that industry. Last October he formally opened the coal hydrogenation plant of Imperial Chemical Industries at Billingham, and the interest he displayed in personally studying the plant showed that he was appreciative of the remarkable achievements and the high standard of British chemical plant manufacture, of which the Billingham installation was a shining example. That visit could not but have impressed Mr. Ramsay MacDonald with the result of the combined efforts of their engineers, both chemical and mechanical, who had shown themselves to be possessed of a skill of no mean order.

As Lord President of the Council, Mr. Ramsay MacDonald was in touch with scientific research in the industrial field, and in fact presided over the scientific and industrial research which was carried out by the Governmental Body of whom they were glad to see several distinguished representatives present that day. The research exhibit organised by the Department of Scientific and Industrial Research provided an illuminating insight into the amount of scientific investigation which the Department was fostering and which bore on chemical engineering. There was no research station of the Department, nor any industrial research association which did not provide useful information of some sort for the chemical

engineer, even though at first sight its activities appeared far removed from chemical engineering. He therefore felt that they in the chemical plant industry should maintain much closer contact with the Department of Scientific and Industrial Research than they had been in the habit of doing.

Mr. W. RUSSELL, in seconding the vote of thanks, referred to the necessity for the closest co-operation between the user and the maker of chemical plant. This was recognised by many important chemical manufacturers. They supplied information as to the requirements of the plant they wanted, its capacity and the quality of the product they desired to get, but there were so many factors involved that it was always advisable to have a detailed discussion with the engineers in charge of operations, and if possible to make small scale tests on the ground on the actual material dealt with. Such a policy would pay purchasers of plant, and after a good many years of experience he could not remember any case where confidence placed in plant manufacturers by purchasers of chemical plant had been abused. The same applied to research. Time and labour would be saved if the research department, whether a Government one or that of an individual plant manufacturer, had all the information available necessary to arrive at a definite conclusion. The co-operation of all three gave conditions ideal for the success of the plant required.

## The Inaugural Luncheon

Nearly four hundred members and guests attended the inaugural luncheon in connection with the exhibition, held at the Hotel Victoria on Monday under the chairmanship of Mr. J. H. G. Monypenny.

Sir DAVID MILNE-WATSON, chairman of the organising committee of the Chemical Engineering Congress, proposed the toast of the British Chemical Plant Manufacturers' Association as organisers of the exhibition. Their task, he said, was the translation of research into practical productive plant, which meant much more than transforming test tubes into iron pots and receptacles. The greater the refinement and the greater the subtlety of chemical thought the more exacting was the demand upon the chemical engineer if he was to do all that was expected of him. He must and did continually achieve higher spheres of knowledge, greater precision of

control, higher pressures and the use of more resistant materials for the treatment of corrosive substances. Those things demanded engineering technique entirely of their own, and except for the laboratory itself he could imagine nothing more arduous in pursuit or more satisfying in achievement than to plan and adopt and apply such structures up to the full working capacity of the modern works. One aspect of the achievement of the chemical engineer which must command special admiration was the variety of needs which he was prepared to meet. Looking through the directory of the Association and the list of services which it offered he found it included something like 500 headings, beginning with alkalis and ending with yeast. The gas industry which he represented was one great chemical process, and perhaps the largest of them all. An important aspect of the work of the



The inaugural luncheon at the Hotel Victoria on Monday, presided over by Mr. J. H. G. Monypenny.

Association was the success with which it was making known what it had to offer. They in the gas industry in the last few years had learnt the value of what used to be called propaganda, but what was now known as "communication." What the Association was offering was not a luxury; it was something the purchaser should use for his own good, and he congratulated the Association upon its exhibition.

The CHAIRMAN, in responding to the toast, said the organisation of the exhibition was due in large measure to the excellent work of Mr. J. Davidson Pratt and his two able assistants, Mr. Holden and Mr. Drake. Mr. Holden had been responsible for the details of the exhibition, and Mr. Drake for the production of the catalogue. Without those three gentlemen the exhibition would have been a very different thing indeed.

Mr. E. A. ALLIOTT, past chairman of the Association, proposed the toast of the visitors.

Mr. RAMSAY MACDONALD, in responding, observed that his name was coupled with those of representatives of Germany and the United States. For his own part he would do all he

could to impress upon other people that the three of them must be co-operators with each other. No one could escape from the consciousness of the great power that was being raised up in the world in these later years. It was a power that was to be used as the will of man determined. They were joined together in giving thanks for the hospitality that had been extended to them. He wondered if the three of them, each representing his own country, could lay their heads together and remain joined together in moving heaven and earth to ensure that the great world power would never be divided but rather that they would co-operate to promote the blessing and well-being and happiness of mankind. Besides the international guests, he expressed his pleasure at being associated on that occasion with Lord Leverhulme, Sir David Milne-Watson and Sir Harold Hartley.

Dr. C. M. A. STINE, vice-president of E. I. du Pont de Nemours, and Professor Dr. KESSNER, vice-president of Dechema, also responded to the toast expressing their appreciation of the welcome extended to their respective countries.

## A Few Points Worth Recording

EVEN a casual inspection of the 1936 British Chemical Plant Exhibition has shown the visitor that many important developments have taken place in chemical engineering since the last exhibition of 1931. A more critical inspection, coupled with the knowledge that at least 75 per cent. of the cost of production of an exhibited item had to represent British labour or material, has made it clear that British chemical plant of the highest quality and efficiency is now obtainable to meet every conceivable need of the manufacturer of chemicals and such related products as paints and plastics. Since much plant, as designed for the making of chemicals, is now adopted for the processing of food products, visitors who are especially interested in food products have been equally well convinced of progress in this direction.

The diverse nature of the liquids, solids and gases which are handled, now demands a very wide range of constructional materials for chemical plant. Aluminium, copper, nickel, stainless steel, and other metals are represented by their respective specialist firms, such as the Aluminium Plant and Vessel Co., and Firth-Vickers Stainless Steels, Ltd., but silver-lined plant (although supplied in quantity by one well-known precious metal refiner) does not appear to be exhibited except in the instance of a steam jacketed pan by Bennett, Sons, and Shears, Ltd.

### Glass Lined Steel and Stoneware

In another direction there are three firms exhibiting glass-lined and enamelled steel or cast iron. Glass-lined steel equipment, as supplied by Enamelled Metal Products Corporation, is the works counterpart of laboratory glassware, giving perfect protection against metallic contamination and a resulting high degree of purity for the product handled. A glass-lined distillation unit, complete with agitator, jacketed condenser and receiver, is one of the items exhibited by this firm, whose works are in Scotland. Cast iron, lined with special hard grey acid-resisting enamel, is featured by Cannon Iron Foundries, and the plant here shown includes steam-jacketed pans of British Standard shallow and deep patterns, as well as autoclaves and mixing digestors. An open type steam-jacketed mixer for heavy viscous products, constructed in acid-resisting enamelled cast-iron, is to be seen on the stand of T. and C. Clark and Co.

The range of chemical stoneware is equally impressive, three competitors again being represented. At the stand occupied by Doulton and Co., a large number of items are exhibited in the new white stoneware, which is strikingly noticeable alongside the more familiar brown salt-glazed ware. Large cocks, conical flanged pipes, and white glazed hall and partition tiles are a special feature at this stand. Hatherware, Ltd., also exhibit high-class chemical stoneware of the white variety, but also show an absorption tower, com-

plete with distributing and perforated plates made in the firm's new "Greyware," which has a dense grey body covered by a brown glaze. Another exhibitor of stoneware is George Skey and Co. Rubber-lined plant is noticeably absent among the non-metallic material of construction.

Among designs not shown at the 1931 British Chemical Plant Exhibitions special attention might be drawn to about one hundred items, representing the efforts of thirty plant manufacturers out of a total of forty-eight exhibitors. A small plant, made of welded nickel, for the manufacture of synthetic resins, falls into this category at the stand of the Aluminium Plant and Vessel Co., who continue to display their patent leakproof cocks. The section of a new design in jacketed vessels which obviates the necessity for penetrating the inner shell for the stays, thus reducing possible sources of leakage to the minimum, is shown by Ashmore, Benson, Pease and Co. The Audley Engineering Co. exhibit patent lubricated plug and disc valves, as well as "Audco" valves for working pressures up to 3,000 lb. per square inch. A modern autoclave of two litres capacity, designed to work at temperatures up to 450° C. at 250 atmospheres pressure, is a feature of interest among the exhibits of Hadfields, Ltd., all the vital parts of this equipment having been made of forged "Hecla-134" alloy steel. The Hydronyl Syndicate, Ltd., with an attractive display of contact rings of the plain cylindrical and Lessing types, show the first British-made carbon contact rings for use with highly corrosive acids or caustic alkali.

### Unit Process Equipment

Five exhibitors are present to interest the user of centrifugal drying and separating machinery, laboratory centrifuges being included at two of the stands. Thomas Broadbent and Sons have a new type 48-inch direct electrically-driven centrifugal fitted with imperforate basket and skimming gear, a machine which is used for precipitating solid matter held in suspension by a liquid; the exhibit of Watson, Laidlaw and Co., is confined to a 36-inch suspended belt-driven centrifugal and a centrifugal basket made entirely of Monel metal. Crushing, grinding, and screening machinery users are to be enlightened at the stand occupied by International Combustion, Ltd., where there is a new constant weight feeder to enable plant to work at maximum continuous duty without fear of under- or overloading.

Machinery for drying by hot air or steam heating is exhibited by four firms. In this category Manlove, Alliott and Co., are showing a semi-conical double drum or "film" dryer, and model working sections of rotary dryers; George Scott and Son have a patent vacuum continuous-band dryer, which is unique in the facilities which it affords for drying and grinding, where desired, continuously under vacuum. At the stand

of George Scott and Son there is also a patent high vacuum distillation plant for glycerine (capable of producing B.P. glycerine in one distillation), and a patent forced circulation evaporator in which high liquor velocities give unsurpassed evaporation efficiencies and concentrations.

For visitors interested in filtration equipment S. H. Johnson and Co., have a display of filter plates and frames of various types and sizes, constructed in wood, iron and bakelite, together with complete filter presses, and Manlove, Alliott and Co. are showing enclosed pressure filters and filtercloth washing machines. The Dörr-Oliver Co. exhibit models of the principal types of plant in which they specialise, including thickeners, vacuum filters, pressure filters, and plant for the continuous washing and decantation of finely divided solids. The Kestner Evaporator and Engineering Co. have their Isoelectric high temperature heat treatment and polymerising plant for vegetable oils in operation, and a display of "Keebush" tanks, pipes, valves and fittings.

At other stands the visitor can inspect a display of safety appliances (Siebe, Gorman and Co.), sieve vibrating machines (Stevens and Manning, Pascall Engineering Co., and Thomas Locker and Co.), automatic water stills (Manesty Machines, Ltd.), meters for air, steam, water, etc., and automatic controllers for temperature, pressure, etc. (George Kent, Ltd., and Negretti and Zambra), stainless steel screening cloth (Thomas Locker and Co., and Stevens and Manning), and colloid mills (Premier Colloid Mills, Ltd.). On the last-named stand there is a laboratory type high speed mill fitted in Monel metal, and a corrugated mill (the latest improvement in emulsifying machines) fitted throughout in stainless steel. Diaphragm valves employing a new streamline principle are exhibited by the Saunders Valve Co.; electrolytic cells producing hydrogen and oxygen are displayed by the International Electrolytic Plant Co.; and an ideal pump for filterpress work is shown by the Tungstone Patent High Pressure Die Casting Co.

## Membership of the Congress

### Great Britain Heads the List with 404

ACCORDING to the official list issued on Monday there are 682 members of the Chemical Engineering Congress. Great Britain heads the list with 404, the United States comes second with 82, and Germany third with 44. The following seven international organisations are officially represented:

*International Gas Union*: A. BARIL (France). *International Federation of the National Standardising Associations (Isa)*: N. FREDRIKSSON (Sweden). *International Association for Testing Materials*: H. J. GOUGH (Great Britain). *International Electrotechnical Commission*: C. LE MAISTRE (Great Britain). *International Chamber of Commerce*: LORD LUKE (Great Britain). *Institut International Du Froid*: R. PLANK (Germany). *Union Internationale de Chimie*: J. F. THORPE (Great Britain).

Following are the official Government delegates from overseas countries. National Committee official delegates are indicated by the letters N.C., and the number of delegates from each country is given in parentheses.

ANGLO-EGYPTIAN SUDAN (1).—D. W. COWIE.  
AUSTRALIA (3).—W. RUSSELL, GRIMWADE, Melbourne (N.C.).  
H. HERMAN (Government and N.C.).  
AUSTRIA (4).—H. MARK, W. MULLER.  
BELGIUM (7).—BRECKPOT, Namur (N.C.).—DONY-HENAU, P. ERCULISSE (N.C.), A. GILLET, —, MERTENS (N.C.).  
CANADA (5).—L. F. GOODWIN (N.C.), F. W. SKIRROW (N.C.).  
—, STRATFORD (N.C.), G. S. WHITBY, A. W. G. WILSON.  
CHINA (2).—S. Z. WANG.  
CZECHOSLOVAKIA (2).—E. DOLENSKY (N.C.), F. PERNA (N.C.).  
DENMARK (9).—C. JACOBSEN, K. E. JENSEN (N.C.), P. E. RAASCHOU, T. C. THOMSEN (N.S.).  
DOMINICAN REPUBLIC (2).—M. HENRIQUEZ-URENA, R. H. KULKA.  
ESTONIA (1).—J. KOPWILLEM.  
FINLAND (1).—V. I. SIHVONEN.  
FRANCE (9).—H. CABELLE, J. GERARD (N.S.), P. LION (N.C.), PERRIN (N.C.).  
GERMANY (44).—K. DIETZ (N.C.), S. ERK, C. MATSCHOSS (N.C.), B. MULERT, Taubenstrasse 16/18, Berlin, A. W. SCHMIDT (N.C.).  
GREECE (2).—P. ALMANACHOS, C. KAWASSIADES.  
HUNGARY (3).—J. VARGA.  
INDIA (2).—A. JARDINE (N.C.).  
IRELAND (4).—L. J. KETTLE (N.C.), T. J. NOLAN, P. F. PURCELL (N.C.), W. TATLOW (N.C.).  
JAPAN (29).—M. KAMO (N.C.), K. KANEKO, Y. KOSAKA (N.C.), Y. OSHIMA, M. YANAGIDA (N.S.).  
LATVIA (1).—J. AUSKAPS (Government and N.C.).  
NETHERLANDS (13).—J. PFEIFFER, H. I. WATERMAN (N.C.).  
NETHERLANDS EAST INDIES (2).—W. COOL, (N.C.), H. J. van LOUWEN (N.C.).  
NEW ZEALAND (2).—H. G. DENHAM, R. J. HARVEY.  
NORWAY (1).—E. SVANOE (N.S.).  
POLAND (6).—S. PILAT (N.C.).  
ROUMANIA (1).—C. D. BUSILA.  
SWEDEN (13).—G. H. HULTMAN, S. NAUCKHOFF.  
SWITZERLAND (9).—F. ESCHER (N.C.), P. SCHLAPFER (N.C.).  
UNION OF SOUTH AFRICA (3).—J. G. LAWN (N.C.), C. F. LOGEMAN (N.C.), C. D. TERRY (N.C.).  
UNION OF SOVIET SOCIALIST REPUBLICS (8).—E.

BRITZKE (N.C.), N. GELPERIN (N.C.), A. KARZEV (N.C.), D. KOTT N. USHKEVITCH.  
UNITED STATES (82).—J. V. N. DOOR., M. H. ITTNER, JACKSON (N.C.), J. G. VAIL (N.C.), F. C. ZEISBERG (N.C.).

## Methyl Bromide Fire Protection

### Demonstration at Richmond

ON June 18 the National Fire Protection Co., Ltd., of Richmond, gave, at Richmond Fire Station, a demonstration of their "Essex" methyl bromide fire-fighting installations. This took the form of igniting and extinguishing oil in a transformer 5 ft. high, together with various cables and oil drums, all housed in an iron hut 20 ft. square and 8 ft. high. To give verisimilitude to the fire 40 gal. of transformer oil in trays having a total area of 120 sq. ft., and circulating oil continually pumped from outside over the transformer, were ignited. The equipment set to deal with the situation consisted of two No. 6 "Essex" mechanical automatic units, supplying eight discharge pipes, and actuated by two fusible links which also operated an alarm bell, a light indicator, and the door and vent-hold closing device.

The oil was ignited by five pieces of flaming cotton waste, and from the moment of ignition to the commencement of operation by the extinguishers thirty seconds elapsed; from the moment of discharge to the extinction of the fire, twelve seconds, and a further period of twelve seconds completed the discharge from the extinguishers. A re-ignition test carried out after an interval of five minutes showed that the atmosphere still would not support combustion. A further test was carried out on flaming oil in the open air, comparing the methyl bromide with the carbon dioxide foam method, in which two 3 gal. methyl bromide containers extinguished in 20.8 seconds a fire requiring two and a half 2 gal. foam containers working for 68.8 seconds.

A No. 2 size "Essex" extinguisher was tested by the Faraday House Testing Laboratories for its suitability for use in coping with electrical fires. For this purpose a metal plate was suspended from insulators and connected to the high tension terminal of a transformer, through an instrument for measuring the amount of current flowing. The metal case of the extinguisher was then connected to the other terminal of the transformer, which was earthed. The jet from the extinguisher was directed on to the metal plate from a distance of 2½ ft., and the pressure across the transformer terminals increased to 22 500 V.

At this pressure there was a current of about 26 micro-amperes flowing, an extremely small current, representing an impedance of 865 megohms, due to the jet of fluid, a resistance sufficient to render the appliance safe for use on live electrical wires.



# The Chemical Engineering Congress

## The Duke of Kent pays Tribute to the Chemical Engineer

**I**N the presence of representatives of nearly forty of the leading industrial nations of the world, the Duke of Kent opened the Chemical Engineering Congress of the World Power Conference at the Central Hall, Westminster, on Monday afternoon. Lord Leverhulme, president of the Congress, was in the chair, and the heads of all the overseas delegations, together with the presidents of all the British chemical and chemical engineering organisations, were on the platform.

Lord LEVERHULME, in calling upon His Royal Highness to open the Congress, said that when the organising committee and all who had part in the success of this international congress heard that the Duke of Kent had consented to be patron they felt most proud and delighted. They regarded it as a great honour that he was present with them that day in person to declare the Congress open.

The DUKE OF KENT said it was twelve years since his brother, the King, when Prince of Wales, opened the first World Power Conference at Wembley. Since then many of the high hopes of which he spoke had been realised. The World Power Conference, by means of the meetings which it had held in Berlin, Basle, London, Barcelona, Tokio and Scandinavia, had proved itself effective in securing international co-operation between engineers, technicians and administrators. Next September there was to be the third World Power Conference at Washington, at the invitation of the United States Government, and he knew many of those present that day were looking forward to that event. He wanted to express a warm welcome to all the delegates and members who had come to London from overseas. He knew from his own experience what a fine welcome and what charming hospitality greeted his countrymen when they went abroad, and he hoped they would be able to return that kindness and hospitality on the present occasion.

Science was even more fortunate than the arts and literature in its freedom from national limits. Proud as each country was of the achievements of its great scientists and inventors, their work once done became international and contributed to the well-being and happiness of every race. The present century had seen the development of science more rapid, more wide and more fundamental than in any previous age, and no profession had been more ready or more skilful than that of the chemical engineer in the use of the new resources which science had been able to offer. Chemical engineering was one of the most modern professions, and that day, on the occasion of the opening of its first international congress, it came of age. It had made such progress that it had entirely altered the meaning of the word "artificial." At one time "artificial" implied some measure of inferiority, but to-day there was no such stigma attached to its modern equivalent "synthetic." To give one example, when we

were threatened with a lack of fertilisers the chemical engineer supplied the need almost too abundantly. After their recent success in meeting so many of the needs of mankind it seemed impossible to set any limits to their achievements in the future. Those successes had been due to the union of the engineer and the chemist, symbolised in the title chemical engineer.

When visiting factories he had been able to see evidence of the co-operation between the engineer and the chemist and he had been amazed at the skill with which the chemical engineer had enabled chemical reactions to be carried out on a gigantic scale with certain control and under conditions of the utmost safety for the worker. It was an achievement of which they might feel proud.

They now met for their first international Congress to compare notes of their progress and to discuss their problems, to meet one another and to renew or to form friendships which were the happiest results of such gatherings. May their deliberations be successful and may they carry home with them the happiest recollections of those few days spent in London. He hoped the effects of the Congress would extend far beyond the technical confines of their immediate discussions, and he had great pleasure in declaring the Congress open.

Lord LEVERHULME thanked His Royal Highness for opening the Congress. They all felt that by coming to open the Congress he had rendered a great service to the cause of international co-operation in the field of chemical engineering, a cause to the importance of which he had borne such excellent testimony.

Proceeding to deliver his presidential address, Lord Leverhulme said the chemical engineer had been defined as a "man experienced in the design, construction and operation of plant and works in which matter undergoes a change of state and composition." The definition brought out the essential fact that a chemical engineer was first and foremost an engineer, although of course his need for chemical knowledge immediately arose from the fact that the particular plant which he constructed was required to handle materials upon which it would, chemically speaking, have some affect and which would in turn be affected by them. He did not suggest that a chemical engineer was simply an engineer upon whom had been superimposed a veneer of chemical knowledge. Indeed this was far from being the case, for the true chemical engineer could only be evolved as the result of a highly specialised training, which would, among other things, ensure that his knowledge of chemistry was such that he could fully comprehend the work of the research chemist in the laboratory, and then reproduce in the factory the reaction which had been studied on the research bench.

Chemical engineering had been recognised as a distinct science for the past fifty years, and its early development, at



The Duke of Kent with Lord Leverhulme on his arrival to open the Congress at Westminster on Monday.

any rate in this country, was largely governed by the very considerable growth in the heavy chemical industries during the closing decades of the 19th century. The pioneer work in the field of chemical engineering was mainly carried out in Germany and the United States, and it was not until the changed economic conditions of the war and immediate post-war period had stimulated the manufacture of chemical products of all kinds that chemical engineering began to receive in Great Britain the attention which it merited. The more recent history of the development of chemical engineering was readily illustrated in the rapidly widening range of industries with which the chemical engineer was being associated. The extent to which the work of the chemical engineer entered to-day into the manufacture of articles in common daily use was positively bewildering.

### The Guardian of Health and Pocket

To the layman, did he but know it, the chemical engineer manifested himself in a diversity of ways. He guarded his health and his pocket. He was a welfare worker and a preserver of man's greatest heritage—the products of nature. To the layman in his capacity of consumer the chemical engineer was revealed in two ways—in lower price and in improved quality. In this matter of price the chemical engineer has set new low standards for a considerable range of products. He had achieved this through producing synthetically materials, the high cost of which had in the past greatly added to the price of the finished article. The high cost was sometimes due to nature's inability to produce the material in question in sufficient quantities; sometimes to the prevalent economic nationalism of our times; and sometimes to both. Whatever the cause the chemical engineer had already in many cases nullified it by the development of substitutes, and would continue to do so to an increasing extent in the future. The manufacture of raw materials from synthetic resins was a case in point, and the extent to which plastics entered into the commoner articles of daily use provided some indication of the extent of the influence which the chemical engineer exerted to-day upon our economic structure.

In many manufacturing processes the corrosion and wear and tear of the plant, caused by the chemicals which it was handling, presented a serious problem and one which was among the chemical engineer's earliest lines of inquiry, so that to-day we found that a great saving was being effected in plant construction by the introduction of those materials best able to resist chemical action. Similarly, but much more recently, the chemical engineer had revolutionised our standards of purity for many products, and this had also been achieved through improvements in the manufacturing process.

### Conserving the World's Resources

The chemical engineer conserved the resources of our world in a diversity of ways; he went far towards ensuring that each material was put to the most economical use possible, he enabled us to make use of materials which could not otherwise be economically exploited, and he developed substitutes and thereby released more costly materials for use in other processes where it had in the past perhaps been impossible to make sufficient use of them. In years to come it would, he thought, be precisely for this conservation of our resources that the chemical engineer would receive the greatest recognition from a world wherein the gradual exhaustion of Nature's resources was being accelerated by the increasingly heavy demands made upon them.

The synthetic production of ammonia, of rubber, of petrol, of foodstuffs, and a hundred and one commodities in general use to-day—these were but portents of an economic revolution the proximity and the scope of which were insufficiently appreciated by the great majority. The time was not far distant when man, largely independent of the accident of geographic or climatic environment, would come to rely to a very considerable extent upon that universal provider of substitutes—the chemical engineer.

Scientific progress was becoming increasingly complex and the various branches of science increasingly interdependent. Thus when we found, for example, that the work of the chemical engineer was becoming more dependent on the development of high pressure/high temperature technique, we found also that this development was in turn conditioned by the progress, which was being made by the metallurgist in the production of metals and alloys better able to stand the strain, which high pressure/high temperature technique imposed upon modern chemical plant. The chemical engineer would encounter in the future as he had in the past, many obstacles, which unaided he would be unable to overcome, yet overcome them he would and as he was helped in solving his own problems, so would he in his turn be able to help others to solve theirs.

### Pressure Mindedness

He would like to revert for a moment to the problem of high pressure technique, because he felt convinced that it was along these lines that we were destined to see the most noticeable developments in chemical engineering during the next few years. If he might be allowed to make a suggestion to those who were primarily concerned with chemical engineering in its educational aspects, it was that they should make sure that the coming generation of chemical engineers were pressure minded.

Chemical engineering, by whatever name it might be called, was to-day practised all over the world, and occupied a position of prime importance in our world economy, but as was inevitable with all applied sciences having such a relatively short history behind them, chemical engineering had developed very unevenly in different countries, both as regards the actual progress which had been achieved and as regards the relative importance which each country placed on the various aspects of the science. For these reasons it had long been felt by many people that it was time for the chemical engineer to review his progress and to consolidate his achievements. The varied development of chemical engineering in different countries meant that this work of revision and consolidation could only be undertaken on an international basis, and it was from this fact that the conception of an international chemical engineering congress gradually emerged in this country.

They would witness the ultimate realisation of this conception during the week, and he thought they would agree that the standard of papers presented to the congress bore eloquent testimony to the fact that the subjects which they would be discussing, offered ample opportunity for this work of revision and consolidation.

### The late Sir Frederic Nathan

The idea of holding a chemical engineering congress in London ultimately found practical expression in the initiative of one man—the late Sir Frederic Nathan, a past-president of the Institution of Chemical Engineers. Those who had had any experience of the amount and trying nature of the work required in the initial stages of organising such a convention would be able more easily to appreciate the debt which they owed to Sir Frederic when he told them that but for him he doubted whether there would have been a congress at all. One or two of his former colleagues on the Council of the Institution of Chemical Engineers would share his pleasant recollections of lunching with him at his club some four years ago when the conception of this congress was discussed. They remembered how keen he was on its being held and what high hopes he had of its results. All his old friends would deeply regret his not being spared to see his hopes realised and to witness the success with which his labours had been rewarded.

If it was Sir Frederic Nathan who turned the congress from an idea into a reality, it was to the International Executive Council, and to the National Committees of the World Power Conference which must go the credit for making the congress the international success which it promised to be. Had the World Power Conference not existed,

and offered them its generous co-operation, it would have been necessary to have created their own machinery for the promotion of participation from overseas, with a result which might well have fallen short of what had actually been achieved. They had had the advantage of the great experience and enthusiastic assistance of the National Committees of the World Power Conference throughout the world in organising participation by their respective countries. They were proud that the congress was being held under the auspices of the World Power Conference.

The relation of the Congress to the World Power Conference was not purely one of organisation. The main purpose of the World Power Conference was to bring together those directly concerned with the power and fuel industries in each country—both producers and consumers—in order to ensure that their problems were considered from an international as well as a national standpoint. His Royal Highness had already said how well it is achieving its object; and the wide range of the interests and activities which it covered was shown in the programmes of its meetings.

The association of chemical engineering with the World Power Conference was not fortuitous, for the contents of the papers to be read showed what a close relationship existed

between them. Were not the energy requirements of a chemical process the fundamental consideration in its translation to a works scale? Then, too, so many of the problems of chemical engineering, which they would be considering, had a direct application in the fuel and power industries, and he had no doubt that their discussions would make a valuable contribution to the work of the World Power Conference by helping towards the solution of many problems which were its direct concern.

It is a great pleasure to those in Great Britain to be acting as hosts for the Congress. They were, however, fully conscious that this pleasure carried with it great responsibilities, and they would only consider that their efforts in sponsoring the Congress had been successful if, on looking back, they could honestly say that they had, through the Congress, made a worthwhile contribution to that task of international revision and consolidation with which he felt it such a privilege to be associated.

Thanks to the Duke of Kent and greetings from their respective countries, were afterwards expressed by M. H. Cabelle (France), Dr. B. Mulert (Germany), Dr. Y. Oshima (Japan), Dr. J. Pfeiffer (Netherlands), Mr. N. Ushkevitch (U.S.S.R.), and Dr. M. H. Ittner (United States).

## Some of the Congress Officials



Sir David Milne-Watson, Chairman of the Organising Committee.



Sir Alexander Gibb, Chairman of the Hospitality Committee.



Mr. W. A. S. Calder, Chairman of the Technical Committee.



Mr. J. Davidson Pratt, Chairman of the Finance Committee.



Mr. M. W. Burt, General Secretary of the Congress.



Dr. E. W. Smith, Chairman of the Publicity Committee.



## Ferrous Metals in Chemical Plant Construction—Section A

By W. H. HATFIELD

*A1. Forgings for the Handling of Fluids at High Temperatures and Pressures. (Gt. Britain.) By H. H. Burton, W. H. Hatfield and T. M. Service. A2. Heat-, Rust-, and Acid-resisting Steels. (Gt. Britain.) By W. H. Hatfield. A3 Steels for Autoclaves (Gt. Britain.) By R. J. Sarjant and T. H. Middleham. A5. Modern Cast Irons in Chemical Plant Equipment. (Gt. Britain.) By J. G. Pearce. A6. Some Aspects of the Behaviour of Carbon and Molybdenum Steels at High Temperatures. (Gt. Britain.) By C. H. M. Jenkins, H. J. Tapsell, G. A. Mellor and A. E. Johnson. A7. Corrosion and Protection of Cast-iron and Steel Pipe-lines in the Soil. (Holland.) By C. A. H. von Wolzogen Kühr and J. Ph. Pfeiffer. A8. Use of Cast Iron in the Chemical Industry. (United States.) By H. L. Maxwell.*

### Behaviour of Steels

C. H. M. Jenkins and others (*A6*) give an account of some important data arising out of a study of the creep and corrosion of certain carbon and molybdenum steels at superheated steam temperatures. The object of the study was to examine the effect of additions of alloying elements to carbon steels, molybdenum being chosen in the first place in view of its value in improving the creep properties of steel. The chief matter of interest in the work on carbon steels is that some steels were found to be unusually weak, flow taking place at high rates under a given load compared with the other carbon steels. This weakness was evident in castings as well as wrought bars from the same melt. With regard to the molybdenum steels, it is shown that the creep properties of the steels vary markedly with heat treatment. The author refers to the fact that much attention is being given to the question of the intercrystalline cracking of the molybdenum steels at temperatures around 550°C., and that tests are being made to determine whether or not intercrystalline cracking is likely to develop after a long period at service stresses. In the tests on the corrosion of wires between 500°C. and 600°C. in synthetic flue gas, little difference has been found in the rate of corrosion of the carbon and molybdenum steel.

### Forgings for Handling Fluids

In the design of vessels which operate at high temperatures and pressures, such as boiler drums and reaction chambers for chemical processes, the engineer is continually faced with the problem of deciding upon the steels which are best suited to his purpose, and his choice of materials is obviously governed to a large extent by the operating conditions of the plant he is engaged upon. An equally important problem is that of deciding upon the permissible working temperatures and stresses in a vessel made from a particular type of steel, especially where it is essential that wall thicknesses should be fixed at the minimum which is consistent with safe working.

H. H. Burton, W. H. Hatfield and T. M. Service (*A1*) have devoted considerable attention to these problems, and have indicated the various factors which should be taken into consideration in the design of forgings operating at high temperatures and pressures. With boiler drums, for example, research work has established the importance of "creep" when the pressure and temperature exceed certain maxima, whilst at lower temperatures and pressures the "proof stress" obtained from a short-time high-temperature tensile test is shown to be a safer basis for design purposes. Steels designed to resist hydrogen attack at elevated temperatures have received considerable attention during recent years, and the properties at elevated temperatures of several of these steels are discussed, an interesting feature of the chromium and molybdenum steels being the tendency for an increase in the chromium content to be accompanied by a



Dr. W. H. Hatfield, F.R.S.

decrease in resistance to "creep" at a given temperature, though the resistance to hydrogen attack is increased. The authors also review of some of the types of steel which are available for future development, probably involving pressures and temperatures higher than those now employed.

### Steels for Autoclaves

R. J. Sarjant and T. H. Middleham (*A3*) give a review of the operating conditions of the processes in which autoclaves are used, and of the bearing of the principles of design on the stresses produced, in order to arrive at an assessment of the properties required in the steels used in their construction. The most important mechanical properties are indicated as being resistance to creep and to embrittlement during extended heating. Immunity from attack by the contents of the vessel is necessary and though corrosion by liquid agents can be to some extent minimised by the use of loose linings of special character, the effects of gases, and particularly of hydrogen, impose further restrictions on the choice of suitable alloys. Representative corrosion tests on various types of steel in a wide range of chemical agents indicate the degree of resistance to corrosion of the different grades.

A survey of all the best known and used types of corrosion-resisting and heat-resisting steels available at the present time is given by W. H. Hatfield (*A2*). Applications of steels in all the important branches of chemical engineering and the chemical industry are considered in detail. This is done under the headings of the different industries, and not only is the resistance of one or other of the steels to the particular condition indicated, but also considerable information is given as to particular items of plant for which the steels in question are actually being used, or may be used, with advantage. Furthermore, certain conditions and applications are given for which the steels are not suitable. The industries covered in the portion of the paper devoted to applications range from power raising (including steam, hydraulic and electrical plant) to manufacturing (including the manufacture of all types of acids, alkalis, cellulose, glass, paint, rubber, soap, fine chemicals, and foodstuffs) and processing industries such as dyeing and bleaching, photographic work, refrigeration, etc.

### Modern Cast Irons

Developments in cast irons of interest to the chemical engineer are discussed by J. G. Pearce, who (*A5*) refers to increased resistance to mechanical stress (*i.e.* strength) to heat, and to corrosion. The general improvement in foundry technique and in the greater control of melting and moulding processes contributes to this resistance in all these directions by increased soundness and homogeneity. Through modern metallurgical developments, tensile strengths of the order of 30 tons per sq. in. have now been reached.

Resistance of cast iron to heat can be improved in various ways. White irons, where practicable, may be used with or without carbides stabilised by such elements as chromium, nickel-chromium, molybdenum. Grey irons can be similarly treated. The ferritic irons high in silicon and with fine graphite, developed by the Cast Iron Research Association under the name "Sisal," are much more resistant to growth and scaling than grey iron, and are useful where their relative brittleness in the cold does not hamper their application. At elevated temperatures they are stronger than ordinary grey irons. Where greater ductility is required, cast irons can be made austenitic, and two such irons are available for heat-resistance, "Ni-resist" (nickel, copper, chromium) and "Nicrosilal" (nickel, silicon, chromium), the latter being an austenitic type of "Sisal." These irons are the best heat-resisting cast irons available, are highly corrosion-resisting, and are virtually non-magnetic.

Standard tests over many years have shown that cast iron is normally very resistant to ordinary corrosion, but under special conditions much can be done to provide a material showing increased resistance. For ordinary grey irons, small additions of nickel or nickel-chromium are advantageous. Little has been done to improve the well-known acid-resisting, high-silicon irons, but the austenitic irons are soft and easily machinable, take a high finish and are stronger and tougher than ordinary grey iron. They are two to two hundred times as resistant to corrosion as ordinary cast iron, according to the medium, compared in resistance with phosphor bronze. The cast irons containing 35 per cent. of chromium offer better corrosion-resistance than any other type of cast iron, apart from the 15 per cent. silicon irons, and are also highly resistant to heat. They offer good resistance to sulphurous gases and atmospheres.

#### Cast Iron in the Chemical Industry

H. L. Maxwell (48) reviews the properties and some applications of plain and low-alloy cast irons as used under mild conditions of temperature and corrosion, and then proceeds to the more highly alloyed irons used under the more severe service conditions. Attention is directed to the improvements which can be brought about by the addition of small percentages of nickel, chromium, molybdenum, and silicon, and the properties of 4-6 per cent. silicon iron, with and without 2 per cent. chromium, are discussed. The author points out that alloy additions to cast iron, made in order to increase resistance to corrosion, must be carefully adjusted to the actual conditions of service, for whereas a certain alloy addition may bring about a marked improvement in the corrosion-resisting properties for one application, under other conditions this same addition may be most deleterious. Laboratory tests should be carried out in plant liquors, since an unsuspected impurity may be the primary cause of failure, and where possible these tests should be checked in the actual plant equipment.

The material discussed includes the hard cast irons developed for wear-resistance, as, for example, "Ni-Hard" and "Diamite," which, whilst showing sufficient resistance to shock, have a hardness ranging upward to 700 Brinell. Where surface hardening is sufficient, treatments such as nitriding allow Brinell hardnesses up to 900 to be obtained. Data are included relating to the austenitic cast irons, containing 15 to 25 per cent. of total alloy content. These are adapted for use under high temperature and under the most severe corrosion conditions encountered in the chemical industry. The results are given of a series of scaling tests on these irons.

#### Protection of Pipe-lines in the Soil

G. A. H. von Wolzogen Kühr and J. Ph. Pfeiffer (48) discuss the mechanism of soil corrosion and the protection of pipe-lines by bituminous coatings. The problem of finding an entirely satisfactory coating can only be solved by practical trials on actual pipe-lines, though laboratory experiments may be used as a guide in the choice of coatings to be applied

when the relation between these tests and those made on pipe-lines has been found. Bituminous coatings must be impermeable, and adhesion must be satisfactory. Coal-tar pitches and asphaltic bitumens adhere well, but it is advisable to remove mill scale before applying the coating. The choice of a primary coating is important; it must possess good resistance to flow, good resistance to ground pressure, and good resistance to shock. From the results of tests it is concluded that blown asphaltic bitumens are to be preferred to coal-tar pitches.

#### Points from the Discussion

Sir WILLIAM LARKE expressed the view that the research work now being instituted by the British iron and steel industry and the Iron and Steel Research Council had in it the possibilities of making one of the greatest contributions to progress that had ever been attempted. Work was also being carried out in conjunction with the Electrical Research Association, whilst further investigations were being conducted into the behaviour of steel in working under high pressures and high temperatures, it having been made obvious that engineers were desirous of using higher temperatures and pressures than were permitted by the present material.

Dr. T. SWINDEN (United Steel Companies) said that as a result of the very considerable study of special steels which had been made by the company with which he was concerned, the view was very definitely held that chromium-molybdenum steels were most suitable when used at temperatures of 500° C.

Mr. J. H. G. MONYPENNY (Brown Bayley's Steel Works, Ltd.), referring to the tendency for certain steels to show intergranular fracture at high temperatures, said that under certain conditions of stress and temperatures this was by no means confined to mild steel and that type of fracture could be found in practically every steel which had been made.

Mr. R. J. SARJANT (Hadfields, Ltd.) suggested that the outstanding features of these papers was that the embrittlement of steel remains very much an unsolved problem. At the same time he pointed out that the work described in his own paper was undertaken in the first place as a private investigation in collaboration with Professor G. T. Morgan.

Mr. H. A. BURTON (Vickers), joint author of a paper by Dr. Hadfield, Mr. T. M. Service and himself, expressed the view that the cause of embrittlement was not so much due to a low content of molybdenum as probably to variations in the phosphorus content.

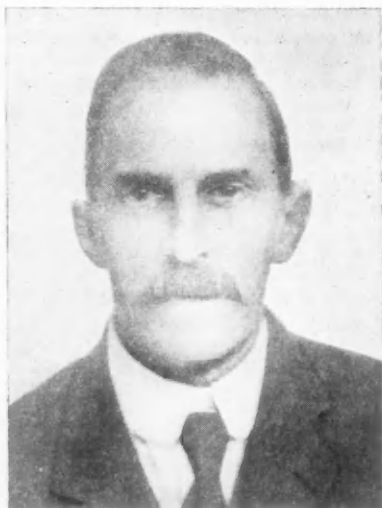
Mr. J. G. PEARCE, in connection with the production of fine graphite cast irons, referred to in his paper, said the method consisted of incorporating in the melt a small quantity of titanium to the extent of 0.2 per cent. and then treating it with an oxidising gas such as CO<sub>2</sub>.

Capt. W. H. CADMAN expressed his disappointment at hearing it stated that metallurgists had not yet solved the problem of embrittlement and at the same time he mentioned experience he had had with steel tubing used in connection with the thermal decomposition of petroleum gases at temperatures from 850° C. upwards in which the tubing became perfectly brittle and split like a glass tube. However, he looked forward to the time when special steels would be available capable of standing up to these high temperatures.

Mr. E. W. COLBECK (I.C.I.) urged steel makers to bear in mind the possibility of chemical reactions up to 10,000 atmospheres and temperatures of 300° C., and even higher, and he asked the steel makers what hopes they had of being able to provide forgings for the conditions indicated.

Dr. W. H. HATFIELD remarked that the presence of SO<sub>2</sub> was a serious problem in steel manufacture. Speaking on embrittlement he said there were conditions of stress, atmosphere and temperature, against which metallurgical research had not been able to provide adequately, but at the same time he claimed a great deal of progress had been made with regard to the problem of embrittlement, and speaking in general terms there was no reason why engineers should be faced with any real problem of embrittlement.

## Refractories, Rubber, Plastics and other Materials in Chemical Plant Construction—Section B



Mr. W. C.  
Hancock.

By W. C. HANCOCK  
and M. B. DONALD



Mr. M. B.  
Donald.

**S**UB-SECTION (a) (refractory materials) of Section B covers the three papers which have been received on refractory materials, namely:—

*B1. New Canadian Refractories and their Application. (Canada.)* By F. E. Lathe. *B2. Refractories for Use in the Carbonising Industries. (Gt. Britain.)* By A. T. Green and F. H. Clews. *B8. Experiments on the Testing of, and the Effect of Reducing Gases on, Grog Bricks for Blast Furnaces. (Japan.)* By Yoshiaki Tadokoro.

The paper by F. E. Lathe (*B1*) deals with the utilisation of extensive deposits of magnesian carbonates found at Grenville, Quebec. In composition, the raw material is not a true magnesite, like the Greek, Austrian, Indian, etc., nor a dolomite, as the lime-content is relatively low, but is intermediate between the two. Attention was directed mainly to the production of products resistant to hydration, chemically bonded brick, and basic and acid cements. The chief applications of these refractories have been in open-hearth steel furnaces, copper smelting and refining furnaces and converters, the high-temperature zone of current kilns, boiler settings and lime-kilns.

The paper by A. T. Green and F. H. Clews (*B2*) gives a valuable survey of the properties required in materials in this special field. Information as to the life of horizontal and vertical retorts, and opinions as to the causes which ultimately render them unfit for service, were collected. The chief materials used are either a lime-bonded silica brick or a highly-siliceous clay-bonded brick, with about 91 per cent. of silica. It is pointed out that slag attack, especially of vertical retorts, may result from the corroding of the slag on the surface of the refractory, or from the penetration of the slag, and its degradation products, into the body of the refractory. The chief factors which influence these reactions are, of course, the chemical composition of the reacting bodies and the temperature in consequence of which the slagging action is localised in zones. Attention is also paid to spalling, that is failure of the refractory to withstand, without rupture, stresses produced by temperature fluctuations or thermal shock. Another form of partial disruption of retorts is the splitting off of thin layers or flakes. Unsuitable jointing cements cause trouble from inadequate refractories, excessive contraction on drying and firing, excessive expansion in use and from lack of bonding power.

The third paper by Yoshiaki Tadokoro (*B8*) contains a critical discussion of physical and mechanical tests applied to some thirty different grog bricks. To compare the amounts of disintegration, the cold crushing strength of an untreated

brick was compared with the cold crushing strength of a specimen which had been maintained at 700°C. for 50 hr. in an atmosphere of carbon monoxide.

### Non-Ferrous and Non-Metallic Materials

(a) *Non-Metallic Materials*: *B3. Stoneware in Chemical Plant Construction. (Gt. Britain.)* By A. Hickman, G. N. Hodson and W. E. Speirs. *B4. Plastics in Chemical Plant Construction. (Gt. Britain.)* By H. V. Potter. *B5. Use of Rubber for Chemical Equipment. (Gt. Britain.)* By S. A. Brazier. *B6. Apparatus for the Study of Heat-Insulating Materials for Use at Low and High Temperatures. (Gt. Britain.)* By Ezer Griffiths. *B7. Chemical Engineering Problems in Relation to the Coarser Textile Fibres: Jute, Coir and Sisal. (Gt. Britain.)* By S. G. Barker. (b) *General and Non-Ferrous Materials*: *B9. Experience with Non-Corroding Materials in the Swedish Chemical Industry. (Sweden.)* By E. Norlin. *B10. Correct and Faulty Treatment of Aluminium Plant. (Germany.)* By H. Röhrig. *B11. Metals and Alloys Used in the Construction of Chemical Plant. (United States.)* By James A. Lee. *B12. Applications of X Rays to the Study of the Annealing of Commercial and Refined Aluminium. (France.)* By Prof. J. J. Trillat.

The papers in sub-section (b) can be most readily divided into (a) those dealing with non-ferrous metals, and (b) those dealing with general and non-metallic materials.

### Non-Ferrous Metals

Dealing with non-ferrous metals first, it would seem suitable to take as a basis the excellent summaries on this subject by J. A. Lee (*B11*) and E. Norlin (*B9*). The former contributes a valuable paper on general American experience in metals and alloys for plant construction (including stainless steels), and the latter a paper on the same subject in the Swedish chemical industry.

Amongst the nickel group of alloys, one of special interest is "Hastelloy" (58 per cent. nickel, 20 per cent. molybdenum and 20 per cent. iron), which can be used for hydrochloric acid and is in competition with soft rubber lining and resin plastic. Copper forms the chief material of construction in breweries, although the reason for its use does not seem to have been fully established; perhaps the connection recently shown between copper and substances rich in vitamin B (e.g., yeast) may be a partial explanation. The field of employment of lead in chemical works construction has been widened recently by the introduction of tellurium lead, which has a very much smaller crystal grain size and allows the metal to be work-hardened.

J. A. Lee (*B11*) gives an able summary of the use of silver and precious metals.



J. J. Tillat (B12) deals with the investigation of grain size in aluminium by X rays. Aluminium is also fully dealt with by H. Röhrig (B10), who refers to the question of loss of tensile strength under the action of heat, and notes that this is due to crystal formation and recrystallisation, and that the threshold of recrystallisation can be moved to the range of higher temperatures by additions of manganese and titanium. Cleaning of aluminium surfaces may give rise to trouble, owing to the fact that aluminium depends upon its surface oxide film for its resistance to chemical attack, and this should not be scratched or broken. Attention is drawn to the use of compounds such as dibenzyl sulphate, which inhibit the action of dilute hydrochloric acid used for removing scale.

### Plastics and Rubber

In the non-metallic section, great strides have been made by the phenol-formaldehyde resin industry in the last few years in the manufacture of chemical plant, and H. V. Potter (B4) has made an important contribution to this question of the utilisation of plastics in chemical works. The chief disadvantage usually attributed to plastic material is its cost. An objection that has been raised to the use of phenol-formaldehyde products for foodstuffs is that they taint the food, owing to removal of traces of phenolic bodies. Rubber is fully treated by S. A. Brazier (B5), who asks if the manufacture of rubber chemical equipment produces laminated rubber to the same degree of tensile strength, heat and shock resistance as is now attained in the competitive resin plastic material.

### Testing of Heat-Insulating Materials

Heat-insulating materials require careful testing to ensure that they maintain their heat resistance during use. Dr. Ezer Griffiths (B6) describes the apparatus used at the National Physical Laboratory for measuring the thermal conductivity of such materials. This apparatus should prove useful in following the improvement of conductivity of stoneware vessels. A comprehensive paper by A. Hickman, G. N. Hudson and W. E. Spiers (B3) emphasises the improvements made in the last thirty years in the heat conductivity of stoneware. It is suggested that more research on lutes and cements assist the chemical engineer to extend the range of chemical stoneware by enabling him to build plant out of unit blocks instead of being tied down to standard sizes and shapes of materials.

### Points from the Discussion

Mr. P. C. KINGSBURY (United States) discussed the question of stoneware in chemical plant and emphasised the improvement that had been made in the physical characteristics of stoneware during the past decade, due to scientific control as compared with the earlier haphazard rule of thumb methods. The present stoneware available provided for the chemical engineer a structural material which within its physical limitations was ideal for the fabrication of chemical plant and equipment. It eliminated the corrosion hazard entirely and thus greatly reduced cost of maintenance. Experiments were also being carried out as regards thermal conductivity by incorporating a silicate material in the grog, and in this way it had been possible to increase the heat transfer four or five times as compared with the ordinary product.

Mr. G. J. GREENFIELD (Thorncliffe Coal Distillation, Ltd.) regretted there was so little data about coke oven refractories in the paper dealing with refractories for use in the carbonising industries, although according to this paper the deterioration of coke oven structures was much less in this and other countries than in gasworks structures. The principal causes of failures in coke ovens were (1) salt or alkali corrosion, (2) squatting under load, but both of these causes were notably absent in high silica ovens. Failure by passage of gas through cracks from vertical retorts to the flues ascribed to the action of water vapour, must surely occur either at special temperatures or by the simultaneous action of some other cause, since comparison between coke oven and vertical retort practice showed that the leakage from the retorts or oven, which it was said damaged the vertical retorts, actually helped coke ovens by sealing up the cracks with deposits of carbon.

Mr. H. D. H. DRANE (Liverpool) said that spalling and cracking were really co-related, and on this general subject of the behaviour and specification performance of refractories he would like to see a linking up of this relatively complex phenomena with the more fundamental and more easily determinable properties of the material. The first requirement was an exact statement of the conditions under which fracture occurred. It was also necessary to include the viscosity of the material and whether it was possible to measure it. He concluded by saying he would like to see the examination and classification of refractories brought back to a correlation with the fundamental properties of the material and so bring the study of refractories and such materials in line with metallurgical questions.

Herr S. KIESSKALT (Germany), referring to comments which had been made as to the desirability of obtaining plastics materials to stand up to high temperature and high pressure, said that such materials were available both in America and Germany, and he mentioned a case in which a vessel, 6 metres high x 12 metres diameter, had been used with complete success, the plastics material in this case not having been softened under heat.

Mr. H. V. POTTER claimed that vessels made of the plastics material described in his paper were infinitely stronger than stoneware and would withstand greater wear and tear than most ceramic type of vessels. Obviously they were not as strong as steel, but at the moment this type of equipment was relatively new and there were no figures so far as he was aware of actual tests with regard to shock. He deprecated the view that rubber and plastics were in competition, because rubber was a plastic material and plastics, in spite of their name, were rigid and the very opposite to rubber.

Mr. A. HICKMAN said there was more scientific research taking place in connection with chemical stoneware than was generally realised and stoneware with an improved heat conductivity was now available. There was little doubt that the various standards now being fixed in this and other countries would be of great value to the chemical engineer, and the stoneware manufacturer would now be able to manufacture his goods to a definite specification instead of under conditions of the old rule of thumb methods of manufacture. The chief improvements which would be brought about as a result of specifications were regularity in composition, regularity in shape (a very important factor for heat conductivity), regularity in thickness, and regularity in buying.

## Separation—Section C

By A. J. V. UNDERWOOD

THE papers included in this section may be divided into three general groups, depending on the type of operation used for effecting separation. Separation may be effected *without* change of phase or physical state, *with* change of phase or physical state, or with the aid of a chemical reaction. Each of these three groups may be further subdivided according

to the mechanism of the operation by which separation is effected:—

I.—SEPARATION WITHOUT CHANGE OF PHASE OR PHYSICAL STATE. (a) *Filtration*. Cg. Filter Presses. (Gt. Britain.) By E. A. Alliot. (b) *Hydraulic Separation*. Cr. Concerning the Theory of Coal Washing. (Holland.) By V. Spée.

II.—SEPARATION WITH CHANGE OF PHASE OR PHYSICAL STATE. (a) *Absorption and Adsorption*. C3. The Designing of Gas Works with reference to the Recovery of Benzole. (Germany.) By F. Plenz. C7. The Recovery of Benzole from Coal Gas. (Gt. Britain.) By W. G. Adam and G. W. Anderson. C10. The Wet Purification of Coke-oven Gas. (Holland.) By H. A. J. Pieters. (b) *Crystallisation*. C20. Crystallisation. (France.) By J. A. Courbis. (c) *Distillation*. C12. Graphical Calculation of Plate Columns. (Sweden.) By E. Oman. C8. Graphical Computations for the Separation of Ternary Mixtures by Distillation. (Gt. Britain.) By L. C. Strang and A. W. Nash. C14. Distillation. (United States.) By G. G. Brown. C2. Recent Advances in Rectification Technology. (Germany.) By E. Kirschbaum. C4. Modern Methods for the Production of Absolute Alcohol. (Germany.) By R. Fritzweiler and K. R. Dietrich. C6. The Production and Treatment of Road Tar in Great Britain. (Gt. Britain.) By W. E. Cone and W. J. Chadder. (d) *Drying*. C15. The Air-drying of Solids. (United States.) By T. K. Sherwood. C19. Drying by Spraying or Atomisation. (France.) By A. Antoni. (e) *Evaporation*. C16. Recent Advances in the Design of Evaporators. (U.S.S.R.) By N. Galperin. (f) *Extraction*. C11. Fractionation of Heavy Oils by Means of Solutions of Gases. (Poland.) By S. Pilat. C18. Chemical Engineering Design of Solvent Extraction Units for Refining Lubricating Oil. (Gt. Britain.) By T. G. Hunter and A. W. Nash.

III.—SEPARATION INVOLVING CHEMICAL SEPARATION. C5. Problems of the Removal of Carbon Monoxide from Town Gas. (Germany.) By R. Mezger. C13. The Modern Cracking Process. (United States.) By Gustav Egloff and Edwin F. Nelson. C17. The Production and Utilisation of Hydrogen from Gases containing Methane. (U.S.S.R.) By W. A. Karzhavin.

E. A. Alliot (C9) gives a comprehensive account of the different types of pressure and vacuum filters commonly used in industrial processes, and sets out the special advantages and disadvantages of each type. Operating data are given for a number of cases, a valuable feature in view of the scarcity of reliable published data on practical operation. A noteworthy feature in the field of filtration is the large number of types of filters, differing radically in construction, which are used, and which apparently justify their use. The reasons for this diversity may possibly be worthy of examination. That property which may conveniently be termed "filtrability" varies so greatly, and is so greatly affected by comparatively small changes in conditions, that the diversity of constructions may be necessary on this ground. It may also be that the elucidation of the complex problem of filtration has not yet been carried far enough, and that further progress in this direction may result in a reduction in number of types of filters.

In dealing with the theory of coal washing, V. Spée (C1) points out that the laws for free-falling spheres cannot be applied to coal and shale particles in a coal-washer, and derives formulae based on the behaviour of a sphere in a narrow tube. The results of experiments are given in support of these formulae.

### Adsorption and Absorption

Of the three papers in this section, two deal with the particular problem of the recovery of benzole from town gas. F. Plenz (C3) and also W. G. Adam and G. W. Anderson (C7) discuss the relative merits of the oil washing process and the active carbon process. Adam and Anderson conclude that for the gas industry the active carbon process still shows some advantages over the oil washing process. The third paper in this section, by H. A. J. Pieters (C10), deals with the removal of hydrogen sulphide from coke-oven gas by scrubbing the gas with a slightly alkaline solution containing a compound which acts as an oxygen carrier, to oxidise the hydrogen sulphide to sulphur, and which is regenerated by aerating the liquid.

The paper on crystallisation by J. A. Courbis (C20) deals with crystallisation from aqueous solutions containing one or more salts. The two methods used industrially, crystallisation by cooling and crystallisation by evaporation, are discussed, and the types of apparatus used for carrying out these operations are briefly described. To complete this survey of crystallisation there would be required a quantitative study of the question of crystal growth in relation to the size-grading of the crystals produced. This question has attracted investigation in recent years, notably in the United States, but much more work still remains to be done.

### Distillation

The calculation of fractionating columns from the equilibrium data, for a mixture is dealt with in the first three papers in this section. E. Oman (C12) describes an interesting method for the case of a binary mixture, which does not involve the assumption of constant molal reflux. L. C. Strang and A. W. Nash (C8) deal with ternary mixtures. G. G. Brown (C14) deals with the difficult problem of multi-component mixtures, discussing plate efficiency, entrainment, and a number of matters relating to column design. Mention is made of a novel type of centrifugal fractionator. Plate efficiency is exhaustively discussed by E. Kirschbaum (C2), who describes a large amount of experimental work carried out to investigate the effect of various factors on the interaction between liquid and vapour on both bubbler-cap plates and perforated plates. A particular distillation problem of great industrial importance is dealt with by R. Fritzweiler and K. R. Dietrich (C4), who reviews the various methods used for the production of absolute alcohol, and give a detailed description of the azeotropic process in which trichlorethylene is used as the entraining agent. The paper by W. E. Cone and W. J. Chadder (C6) puts forward a proposal for creating a national organisation for the treatment and disposal of all tar produced in Great Britain.

### Drying

The two papers on drying, by T. K. Sherwood (C15) and A. Antoni (C19), both draw attention to the mechanism of drying and the necessity for distinguishing between the constant-rate period and the falling-rate period in the drying process. In spray drying, quantitative estimation is further complicated by the fact that the drying surface is not readily susceptible to exact measurement. T. K. Sherwood gives data for the drying of various industrial materials, and draws attention to the fact that, for a given relative humidity, the thermal efficiency of a dryer (not considering radiation losses) increases with the exhaust air temperature. A. Antoni reviews various industrial systems of spray drying.

The paper by N. Galperin (C16) deals with calculations relating to single-effect and multiple-effect evaporators, and also draws attention to modern developments such as vapour recompression and the use as heating media of water under pressure, oil, and the vapours of high-boiling liquids. Mention is also made of the utilisation of heat reaction to effect evaporation.

### Extraction

The use of solvent extraction as a method of separation has developed rapidly in the past few years, especially for the refining of lubricating oils; both the papers in this section deal with this particular problem. S. Pilat (C11) describes an interesting process for the fractionation of a heavy oil, which consists in dissolving the oil in a solvent, such as propane, and forcing in methane under pressure. Under these conditions, the solution separates into two phases containing the heavier and lighter constituents of the original oil. T. G. Hunter and A. W. Nash (C18) deal with the design of solvent extraction units for refining lubricating oil, and give methods of computation using trilinear co-ordinates. The various types of equipment used for extracting the oil with the solvent are discussed, and it is concluded that the most efficient type is a mechanical agitator where continuous counter-current flow of the two liquids takes place actually in the agitator.

Separation processes which depend upon a chemical reaction differ fundamentally from the processes already described in that the separation consists in the removal of one or more components by converting them into other substances, so that they are not separated in their original form, as occurs where physical separation processes are used. Following the chemical reaction, a further separation process of the physical type may be required. In all cases, however, the chemical reaction involved is likely to constitute the most novel feature, the three papers in this section deal mainly

with the reaction part of the process. R. Mezger (C5) describes the process for removing carbon monoxide from town gas by catalytic conversion with steam to carbon dioxide and hydrogen. The costs and heat balance of the process are discussed, and it is pointed out that there is scope for considerable increase in thermal efficiency through improvements in chemical engineering design. The paper by G. Egloff and E. F. Nelson (C13) gives a complete survey of the cracking process. The correlation of the physical properties of an oil with its behaviour in cracking is discussed in some detail. Materials of construction used in cracking plants are also dealt with. The third paper in this section, by W. A. Karzhavin (C17), deals with the production of hydrogen from methane by reaction with steam, and discusses the catalysts used for this purpose, and the use of continuous and intermittent methods of operation.

In reviewing the papers included in this section dealing with processes of separation, it is evident that a very important part is played by physical processes in the work of the chemical engineer. Out of a total of twenty papers, seventeen deal with physical methods of separation—a striking illustration of the fact that the chemical engineer is more frequently concerned with physical operations, and physical effects of chemical reactions, than with chemical considerations.

#### Points from the Discussion

Mr. H. GRIFFITHS, referring to the comparisons made in the paper by Adam and Anderson, said it was necessary that comparisons between systems of benzole extraction should be on an equal basis and there must be strict comparability of conditions. The feature of the activated carbon process was that it enabled high extraction to be achieved and the efficiency of extraction was increased without any increase in the cost of operation. With other processes, the higher the extraction was pushed the greater was the specific cost of energy for the process. The essential feature of the activated carbon process was the carbon replacement cost, namely, 1 kg. of carbon for 1 kg. of benzol recovered (as mentioned in one paper) whilst in another paper there was an indication of a considerable power carbon consumption. It should be borne in mind, however, that this process was constantly being improved and the qualities of carbon now available were

very much better than those available a few years ago.

Mr. G. CLAXTON (National Benzole Co.) said the process mentioned by Dr. Plenz for refining benzoles by means of an inhibitor was invented in 1926 and was applicable to most types of benzole. A considerable degree of commercial success had been obtained with the process and in Great Britain approximately 30 million gallons of benzole were stabilised by the use of inhibitors every year. Benzole of all types had been treated and there had not been a single complaint of gum formation.

Mr. W. H. HOFFERT (National Benzole Co.) said that with the considerable increase in gasworks benzole, he was doubtful whether some of the benzoles produced could be refined successfully to pass the well known acid wash test. New processes, however, had been developed which enabled these benzoles to be refined without difficulty and with comparatively small losses. The biggest problem was the separation of sulphur and although a number of processes had been developed for removing the carbon disulphide, there still seemed some difficulty in disposing of the recovered crude carbon disulphide after it had been separated. A year or two ago it was calculated that the amount of carbon disulphide to be recovered from benzole produced in this country was of the order of 300 to 500 tons per annum. The difficulty of the disposal of carbon disulphide was surprising.

Mr. G. J. GREENFIELD (Thorncliffe Coal Distillation, Ltd.) said that three points raised by Cone and Chadder were of great interest, *viz.*, (1) adequate facilities for the storage and individual treatment for controlled blending of different types of tar, (2) continuous and direct tar fractionation to closely cut products, and (3) corrosion caused by the dissociation of ammonium chloride. Generally speaking, the success of continuous distillation plants of the modern type depended upon uniformity in quality of feed stock to the plants. This could only be guaranteed over any period with tars of differing origin by controlled central blending and storage. With such facilities, operating costs could be lowered and fractionation efficiencies increased as compared with intermittent pot-still operations. The adequate combating of corrosion due to ammonium chloride was a relatively simple matter on continuously operated plants, thereby reducing maintenance costs which were so grievously high in certain sections of the coal tar distilling industry.

## Size Reduction, Grinding and Mixing—Section D (a)

By Professor B. W. HOLMAN

D3. Estimation of Very Finely Divided Solids. (Germany). By H. W. Gonell. D4. New German Technical Development in the Use of Low-grade Fuels (Pulverising and Firing in One Process). (Germany.) By B. Kramer. D5. Control of Fine Grinding and its Theory. (France.) By J. D. Mary.

H. W. Gonell (D3) deals in a thorough and practical manner with the difficult problem of determining, quantitatively, the grain composition (particle diameters) and "specific surface" of powders too fine to screen. The author defines specific surface in terms of square metres per kilogram instead of sq. cm. per gram, *e.g.*, a very fine powder is given as having a specific surface of 1,430 sq. m. per k.g.; this is, of course, equivalent to 14,300 sq. cm. per gm. The author opens with a review of the importance of fine powders in industry and of the immense increase in their production during recent years—"many millions of tons yearly in Germany alone."

The importance of exact knowledge in checking production and assisting in meeting the demands of industry is stressed. In the case of fine powders, we may want to know their space-filling capacity, void content, angle of repose, oil absorption, wettability, and various special properties in addition to their

mechanical state and specific surface. The lower limit of screening or sifting is taken as 0.06 mm. (one four-hundredth of an inch) and the upper limit of colloid solution as 0.1  $\mu$  (one ten-thousandth of a mm.). The use of the microscope for the examination of "particle size" between these limits is briefly considered; the author then passes on to a discussion of Stokes' and Oseens' Laws of falling particles and the



Professor  
B. W.  
Holman.



application of decantation, sedimentation and air elutriation to the estimation of the particle size and grain composition of powders. The types of apparatus recommended are clearly illustrated and described. This section of the paper is of real value to the practising chemical engineer; many useful graphs are given, and the difficulty of dealing with very fine powders is admitted and discussed.

For the examination of very fine powders, the measurement of turbidity, the use of the interference microscope, the employment of X-rays and the application of electronic radiation are reviewed. The measurement of colour shades for comparative valuations is explained. The author shows how much more research is required before the methods of evaluation discussed can be accepted as generally useful in industry for the finest powders.

B. Krämer's paper (*D4*) is essentially descriptive, and deals with the earlier and later examples of the "grinder furnace" or "mill furnace" for steam raising, which pulverise and fire in one process. The descriptions are accompanied by

clear figures and adequate technical data. Steam, both for heating and for power generation, is used so largely in chemical industry that any appliance which will reduce the cost of producing steam is particularly important, and, if that appliance will utilise exceptionally low-grade fuels efficiently, it may render possible the starting up of chemical industries in areas distant from the often over-crowded vicinity of collieries.

Lignite is the only such fuel considered; the author also mentions coal dust, coal washings, middling products and de-dusted coal, but all these low-grade products would have to be used near the collieries because of the cost of their transport. Rather big claims are made for the "mill furnace," for example, that it will burn washing residues; the washery producing the residues would have to be an inefficient one, as the "mill furnace" depends more on its simplicity and compactness for its efficiency than on any new principle of combustion. The furnace was developed in the Golpa-Zschornowitz power plant, where lignite is used.

## Electrolysis and Electrical Applications—Section D (b)

By H. J. T. ELLINGHAM

*D1.* Power: A Raw Material for Chemical Industry. (Canada.) By A. Skelton. *D2.* Electrolytic Water-treatment for the Prevention of Corrosion and Boiler-scale, especially in Hot-water Systems. (Denmark.) By T. C. Thomsen. *D6.* Electrical Pasteurisation of Liquids. (Holland.) By A. H. W. Aten. *D7.* Anodic Oxidation of Aluminium and its Industrial Application. (Japan.) By Akira Miyata. *D8.* Some Properties of Deposits of Low Carbon Steel in Arc Welding. (Japan.) By Prof. Minoru Okada. *D9.* Recent Developments in the Electrochemical Industry in Japan. (Japan.) By Totagoro Tanahashi, Tsutomu Shoji and Motoo Otani. *D10.* An Electrolytic Method of Removing Small Quantities of Iron from Solutions of Aluminium Salts. (Sweden.) By Prof. W. Palmaer. *D11.* Electrometallurgical and Electrochemical Industries based on Hydraulic Power in Norway in 1934. (Norway.) By E. Svanöe.

### Electrolytic Processes

The whole of the world's output of the very "base" metals, aluminium, magnesium, and sodium, is obtained by electrolysis of their molten salts. In paper *D9* reference is made to the use of alunite produced in Chosen, and clay obtained in Manchukuo, as sources of alumina (instead of bauxite) for the extraction of aluminium. Other very base metals, such as calcium, cerium, and more recently beryllium, are also extracted electrolytically from their molten salts on a smaller scale.

The general principle of electrolytic separation of metals, dependent on their relative "baseness" or "nobility" (relative positions in the electrochemical series), is applied in the process described in paper *D10* for the removal of small quantities of iron from solutions of aluminium sulphate by preferential electrode-position of this nobler impurity at a streaming mercury cathode. Decomposition of the purified salt by heat, yields aluminium oxide sufficiently pure for electrolytic reduction to the metal.

The application of electrolysis in a variety of processes for changing or modifying the nature or condition of metallic surfaces is of rapidly increasing importance to a number of industries. Very thin, adherent coatings of one metal electroplated on another can serve to protect the latter against corrosion, as well as, in many cases, to improve its appearance. Copper, nickel, chromium, zinc, cadmium, tin, lead, silver, gold, and most recently rhodium, are among the metals electrodeposited for one or both of these purposes on a large variety of metal goods and fittings. "Composite coatings" consisting of successive deposits of different metals are often produced in order to secure the best combination of protective

value and decorative finish. Electrodeposition of alloys, such as bronze, is also coming into use.

Paper *D7* describes the development of the "anodising" process in Japan. The preparation and use of thick but porous films of good insulating and wear-resisting properties is discussed; and results obtained by superimposing A.C. on D.C. in the formation of the film, and the action of steam in rendering the film non-porous are described.

A process is described in paper *D2* for preventing corrosion and scale formation in boilers by slight electrolysis of the water, using aluminium or iron anodes and the boiler shell as cathode. The efficacy of this treatment is attributed to a decrease in the oxygen content of the water, and an alteration in the nature or concentration of the dissolved calcium salts.

### Electrothermal Processes

Whereas in electrolytic processes there is direct conversion of electrical energy into chemical energy, in electrothermal processes electrical energy is first converted into heat. The ease with which this generation of heat can be confined to a restricted zone enables it to be applied efficiently in bringing about chemical reactions and physical changes which occur only at very high temperatures. Calcium carbide, carborundum, artificial graphite and certain ferro-alloys, are among the substances manufactured entirely by such electrothermal chemical processes.

Individual electrochemical processes (both electrolytic and electrothermal) differ greatly among themselves in regard to the relation between energy consumption and other items of cost. In some, the energy consumption is so large that their economic operation is practically confined to regions where



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power is exceptionally cheap; in others, electrical energy is a relatively unimportant item, and the best location for the process is largely determined by other factors such as proximity to raw materials or markets. Some electrochemical industries are, in fact, established on a considerable scale in practically all civilised countries. The economic operation of processes which can or must be carried out intermittently may depend on their being worked in connection with other industries or as consumers of cheap "off-peak" power.

For those industries which depend particularly on the availability of cheap power, one naturally thinks of countries with abundant water power resources as affording the most suitable sites, but with the development of large, efficient, fuel-fed generating stations and improved systems of distribution, hydro-electric power retains an overwhelming advantage only in those regions where its generation does not involve particularly large capital expenditure. Among countries favoured in possessing such regions are Norway, Canada and Japan; figures given in papers *D11* and *D1* for the cost of power in the two former countries work out at an average of about 0.07d. per kw.-hr. Statistics of production

of materials and power consumption in the great variety of electrochemical industries now established in these three countries, quoted in papers *D11*, *D1* and *D9*, bear witness to the advantages which the possession of readily exploited hydro-electric power confers. Nevertheless, the fact that some other countries not so favoured in this respect have been able to build up and maintain large industries of all these types, shows that this is not the only factor concerned. Moreover, as is stressed in paper *D1*, considerations of national security, limitations of supply of foreign exchange, and the formation of international cartels, have in some cases contributed to the establishment of certain electrochemical industries in countries where they could not be economically maintained against open trade competition. In paper *D11* it is pointed out that the electrochemical industries of Norway have become international undertakings in that large amounts of capital from various foreign countries have been invested in them. Paper *D9* refers to progress in the development of steam-power plants for generation of electricity, and advocates the combined use of steam and water power in the operation of electrochemical industries in Japan.

## Destructive Distillation —Section E

By F. S. SINNATT

*E1.* The Practical Application of the Results of Recent Physico-chemical Research in the Swiss Gas Industry. (Switzerland.) By Prof. P. Schläpfer. *E3.* The Dry Distillation of Wood and its Thermal Balance Sheet. (Austria.) By K. Kietzibl. *E5.* Problems of Control in the Production of Water Gas from Lignite in a Continuous Generator. (Germany.) By H. Müller. *E6.* Manufacture of Town Gas and Gas for Chemical Syntheses from Lignite. (Germany.) By W. Allner. *E7.* Low-temperature Carbonisation of Coal. (Germany.) By F. Müller. *E8.* Development of Chemical Engineering in the Gas Industry. (Gt. Britain.) By T. Campbell Finlayson. *E9.* Town Gas from Brown Coal, Lignite or other Recent Coals. (Hungary.) By J. Györki. *E10.* Recent Development of the Low-temperature Carbonisation Industry in Japan. (Japan.) By Yoshisada Ban. *E11.* Correlation between Coal Analysis and Semi-scale and Industrial Carbonisation. (Sweden.) By S. Qvarfort. *E12.* Underground Gasification of Coals. (U.S.S.R.) By P. A. Chekin, A. I. Semenov and J. S. Galinker. *E13.* Plant Experiments with the Bureau of Mines—American Gas Association Carbonisation Retort. (United States.) By A. C. Fieldner and J. D. Davis.

The most striking impression received from a study of the papers in this section is the diversity of the problems to which attention is being directed in different countries. This would be anticipated from the fact that the types of fuel available differ materially, whilst the local requirements are governed by factors of climate, custom and predominant industries.

### Town and Water Gas

Three papers (*E9*, *E6*, *E5*) deal with the treatment of brown coal as a source of town gas and/or water gas. The manufacture of town gas and/or gas for chemical syntheses from brown coal and lignite is of interest, owing to the importance attached to the synthesis of ammonia, liquid hydrocarbons and lubricating oils, and to the treatment of mixtures of carbon monoxide and hydrogen. J. Györki (*E9*) states that the production of town gas from brown coal is of especial importance to countries where the fuel resources are limited to brown coal. In Hungary, for example, out of a total of 6 million tons of coal over 5 millions are brown coal.

Allner (*E6*) examines the subject of the manufacture of water gas for chemical synthesis, and treats the subject under the heading of producer processes and retort or chamber processes. He concludes an important contribution by saying that the further utilisation of German fuel deposits and the

development of the manufacture of town gas and water gas from brown coal have received a great impetus during recent years. The problem of the production of water gas from lignite in a continuous generator is dealt with in some detail by H. Müller (*E5*). He points out that experiments in the plant with which he is chiefly concerned have led to the development of a technique by which lignite or coke can be successfully converted into water gas. He emphasises the importance of the process in view of the fact that cheap hydrogen is needed for the synthesis of ammonia and motor spirit.

### Low-Temperature Carbonisation

F. Müller (*E7*) investigates the reasons for the failure of many low-temperature carbonisation processes. He states that in nearly all cases a wrong construction of the apparatus, accompanied by a faulty method of heating and a lack of knowledge of the properties of coal have led to their failure. He then reviews the fundamental requirements for the properties of the distillation products. Yoshisada Ban (*E10*) states that the Japanese are accustomed to use charcoal as a



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household fuel, and that the yearly consumption is just over two million tons, though the price is considerably greater than other solid fuels.

P. A. Chekin, A. I. Semenoff and J. S. Galinker (*E12*) state that the cost of the operations associated with the mining of coal can be eliminated largely by gasifying coal underground, the gas being used for generating electric power or transmitted through pipe lines. As a result of the investigations, two new schemes have been adopted for the basis of further work. One instance is given of the Gorlovka Mine, which has been operated since 1935 on blows supplied periodically. The gas produced during the air blow is named "power gas," and is suitable for combustion and heating supply. At present the mine yields 25,000-30,000 cu. m. of power-raising gas per 24 hr., and 12,000-15,000 cu. m. of gas for chemical use. The length of each period with and without air blow varied from 4-6 hr.

S. Qvarfort (*E11*) deals with the correlation between the analysis of coal and the results obtained on a semi-large scale and on a commercial scale. The information is of interest as showing the care with which the large-scale plant is controlled

by experiments on a semi-large scale, and how the results are correlated with the examination of the coal.

In tracing the developments of the gas industry, T. Campbell Finlayson (*E8*) provides details of the part played by engineers and chemists, and he views the duty of the chemical engineer as being not only to advance the industry, but to decide on the merits of existing processes and their relative commercial value.

A. C. Fieldner and J. D. Davis (*E13*) discuss the known laboratory scale apparatus for examining the carbonisation of coal, and then describe the method they have developed, including the preparation of the sample, the details of the electric furnace, and the purifying and condensing train. The apparatus is designed to treat 70 to 300 lb. of coal. The results of a considerable number of blending tests are also given, and a critical examination is made of the products.

P. Schläpfer (*E1*) attempts to survey the development of the gas industry in Switzerland during the past ten years. The conditions are peculiar, in that Switzerland is dependent upon foreign coals, and for economic reasons gas of high calorific value is favoured.

## Treatment and Disposal of Effluents and Waste Materials—Section F (a)

By A. PARKER

*F7. The Treatment and Disposal of Industrial Wastes. (United States.)* By W. L. Stevenson. *F3. The Disposal of Industrial Effluents. (Gt. Britain.)* By H. T. Calvert. *F2. Purification of Waste Water from Yeast Factories. (Denmark.)* By K. E. Jensen. *F4. The Disposal of Gaseous Effluents. (Gt. Britain.)* By W. A. Damon and B. Wylam.

As the first three papers deal with problems of treatment and disposal of industrial waste waters, they can conveniently be considered together as one group. Both W. L. Stevenson (*F7*) and H. T. Calvert (*F3*), who have given valuable reviews of the general, legal and technical aspects of problems of water pollution in America and in Great Britain respectively, stress the importance of devising and applying practicable methods of reducing the pollution of rivers and streams by industrial wastes. Unless satisfactory methods are adopted to a greater extent than at present, there will be increasing difficulty in the provision of ample supplies of water of good quality for domestic, agricultural, industrial and recreational purposes.

There appears to be ample legislation, at least so far as Great Britain is concerned, directed against the pollution of rivers, but means of preventing pollution without undue cost to industry are in many cases unknown. In the past it has frequently been assumed that the production of polluting waste waters is unavoidable, and that the problems can only be solved by devising methods of purification of the wastes before discharge. As a result of investigation, there are cases in which the discharge of industrial waste waters has been avoided by modifications in manufacturing processes, or by simple treatment of the wastes so that they can be re-used.

### Intensive Studies of Processes

More intensive studies of manufacturing processes are urgently required in order to avoid the production of industrial effluents, to recover valuable by-products, or to reduce in quantity and polluting character any effluent necessarily produced. With regard to the investigations required, W. L. Stevenson (*F7*) expresses the opinion that the task is too big for private enterprise, and should be undertaken by the Government with the co-operation of industry. This is proceeding, to some extent, in Great Britain through the Water Pollution Research Board of the Department of Scientific and Industrial Research.

In the appendix to Stevenson's paper, useful descriptions

are given of known processes for the treatment of certain industrial waste waters. The waste waters considered include acid drainage from coal mines, and wastes from gas works, by-product coke ovens, petroleum refineries, the cotton textile industry, wool scouring, pulp mills, leather tanning, corn products, vegetable canning, grain distilleries, and the milk industry.

K. E. Jensen (*F2*) gives a valuable account of a process in operation at a factory at Slagelse for the purification of waste waters from the manufacture of yeast from molasses. It deals with a problem of considerable interest, as many instances have arisen in recent years of difficulty in the disposal of effluents from factories using molasses as raw material in the manufacture of yeast, alcohol and industrial solvents. The method of purification described comprises anaerobic fermentation, sedimentation in ponds, and final treatment by biological oxidation in percolating filters.

W. A. Damon and B. Wylam (*F4*) have provided a survey of methods of treatment of industrial waste gases whereby the noxious constituents may be recovered or destroyed to render the gases inoffensive. Relevant legal enactments in Great



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Britain are explained in the paper, and the toxicities of many of the gases and vapours are tabulated. As examples, suitable methods of treatment of the waste gases from typical industrial processes are described. These processes include the manufacture of hydrochloric acid, sulphuric acid, superphosphate, hypochlorites, and rayon, the distillation of tar, tar products, and ammoniacal liquor, the refining of petroleum, and the generation of electricity.

#### Points from the Discussion

Professor E. BARTOW (State University of Iowa, United States) referred to the valuable work that had been done in America, especially in Chicago and the State of Illinois, in regard to the disposal of industrial waste products, particularly of waste from starch factories. In 1920 the drainage canal from Chicago, and the Illinois River became so foul, owing to effluents from factories in general, and particularly from starch factories, stock yards, and city sewage, that steps were taken to correct the situation, firstly with the object of treating the waste from the starch factories. Measured in terms of biological oxygen consumption, this drainage had been found equal to the pollution load normally coming from a city of 360,000 people. After several years of research, it was determined that the disposal of the effluent could not be done economically, except by trying to lessen the concentration within the starch plant. In some cases the pollution load of, say, 360,000 people had been reduced to what was equal to the pollution load of 17,000 or 18,000. In another case, the plant had been completely "bottled up," the effluents were returned to the plant and reused, the displaced water being returned to the incoming water and used in steeping corn. That strong, heavy water was concentrated and used in feeding; it was sold as "feed."

Dr. McGOWAN said he had not seen anything in the papers about statutory measures of purity, either for liquid or gaseous effluents, except the references in a section of Dr. Calvert's paper. He had always regretted very much that the standard recommendations of the Royal Commission on Sewage Disposal had not been given statutory effect. It would be a good

thing if some influence could be used to bring this about.

Dr. H. D. H. DRANE said it should be possible to deal effectively, he would not say economically, with the carbon disulphide in trade wastes. It was now possible to remove hydrogen sulphide, from 22 parts per million to 2 parts per million, but that was not sufficient for the public. Gaseous effluents were really an engineering subject; the chemical aspect was a secondary one. In this country they used an active carbon which had a very high rate of adsorption. He thought they might have some notes on the different types of carbons which are produced.

Dr. R. LESSING spoke on the treatment of combustion gases, both from the gas point of view and that of effluents. When they came to the consideration of flue gas cleaning processes, as far as sulphur extraction was concerned, they had to deal with wet processes. In the processes which were to be adopted at the Fulham Power Station, as far as gas washing was concerned, it was all plain sailing, but the Port of London Authority insisted on the purity of the effluent going into the river. Dealing with a material like calcium sulphate, and finding the causes of incrustation in the plant, they found super-saturation to a degree, and of a kind which had never been heard of before. It had now, however, been successfully overcome. He agreed with Dr. Calvert that trade wastes should be made use of. Within a very short period, instead of being saddled with the necessity of disposing of all their awkward trade wastes, and that on a very large scale, he thought they would arrive at a time when those trade wastes would actually become a source of profit.

Dr. H. T. CALVERT said that since his paper was written an important step forward had been made. On May 19 there was introduced into the House of Lords a Public Health (Trade Premises) Bill. That Bill had the support of industry, as represented by the factories in British industries generally.

Dr. W. A. DAMON said the rubber industry was already using plant for the recovery of carbon disulphide. With regard to Dr. Drane's remarks, they did not breathe chimney gases. Such gases were diluted many times before they reached the ground as effluents.

## Lubrication—Section F(b)

By H. MOORE

The sub-section on lubrication comprises two papers dealing with processes for refining lubricating oil, and one paper describing a method of ascertaining the chemical constitution of the hydrocarbon ingredients of lubricants:—

F1. Recent Processes which have Increased the Flexibility of the Phenol Process for the Treatment of Lubricating Oils. (Canada.) By R. K. Stratford. F8. Use of Liquid Propane in Dewaxing, Deasphalting and Refining Heavy Oils. (United States.) By R. E. Wilson, P. C. Keith, jun., and R. E. Haylett. F5. Relation between the Properties of Lubricating Oil and its Chemical Structure. (Holland.) By H. I. Waterman and J. J. Leendertse.

R. E. Wilson, R. C. Keith and R. E. Haylett (F8) give considerable details of the physical properties of propane, and describes the plant methods of operating with propane as a refining and dewaxing agent. Their paper includes detailed diagrams of asphalt-oil-propane solutions, and describes the conditions of concentration, temperature, and pressure required for the effective separation of paraffin, asphalt, heavy ends, the so-called naphthenic constituents, and coloured bodies; the advantage of acid-treating lubricating oils whilst in propane solution is explained, whilst the possibility of fractional precipitation is emphasised.

The indications are that future development in the subject of solvent-refining will largely tend towards the study of the exact conditions which bring about various degrees of

extraction, and the finding of means for accurately controlling these conditions. There is every indication that the most successful processes will be those which give greatest flexibility and ease of control combined with efficient recovery of the solvent.

R. K. Stratford (F1) describes recent detail improvements in the application of the well-known phenol solvent-refining process. Developments which have increased the flexibility of the phenol process are described. These consist of an



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ingenious method of reconcentrating phenol from aqueous solution, by scrubbing with the hot oil entering the process.

The paper by H. I. Waterman and J. J. Leendertse (*F5*) describes a method of ascertaining the proportion of naphthenic and paraffin compounds present in saturated hydro-

carbon lubricating oils. The method is based upon the molecular refraction. Aromatic content can be determined by aniline point determination before and after hydrogenation. This information, if generally available, would be a very valuable addition to the results of existing testing methods.

## High Pressure Reactions and High Vacua—Section G

By D. M. NEWITT

G1. Physics of High Vacuum Technology. (Germany.) By Prof. W. Gaede. G3. Applications of High Pressure in the Synthesis of Organic Compounds. (Gt. Britain.) By Prof. G. T. Morgan. G4. Development of an Intermediate-scale Plant for High-pressure Hydrogenation of Tar and Tar Distillates. (Gt. Britain.) By J. G. King and J. Fraser Shaw. G5. High-pressure Chemical Industries in Japan. (Japan.) By Yoshikiyo Oshima. G6. Synthesis of Methanol from Coal. (Japan.) By Takashi Eguchi. G7. Construction of Welded Pressure Vessels for the Petroleum Industry. (United States.) By R. K. Hopkins. G8. Gaseous and Liquid Phase Reactions at High Pressures. (Gt. Britain.) By Prof. W. A. Bone and D. M. Newitt.

### Design for High-Pressure Reactions

In the application of high pressures to industrial processes, questions of plant and equipment design are of considerable importance. It is necessary to provide reaction vessels, pipelines, valves, and other auxiliary equipment capable of withstanding high stresses and of offering resistances to corrosion and chemical attack under particularly severe conditions. Owing to cost, high-grade alloy steels and stainless nickel-chromium alloys can seldom be employed throughout a plant, and various compromises have to be adopted in the interests of economy. In some instances it is possible to design vessels such that the stresses due to internal pressure are supported by an outer casing which may be constructed of mild steel or nickel-steel, whilst the reaction takes place in an inner thin-walled vessel constructed of a highly-resistant alloy.

A typical example of this method is given by J. G. King and J. Fraser Shaw (*G4*). The vessel in question is a converter in which tar is hydrogenated at 200 atm. pressure and 480° C.; the outer casing of the converter is made of a nickel-chromium-molybdenum steel, the walls being 3 in. thick, and the inner reaction chamber of an 18-8 chromium-nickel steel with walls 5/16th in. thick. The outer casing is thermally insulated, but is subjected to the full working pressure whilst the reaction chamber is in contact with the reactants and products at a temperature of *circa* 480° C., but only supports a compressive stress due to the pressure acting uniformly on both sides of the walls. There are circumstances, however, in which this device cannot be employed, and the walls of the vessel have to support the full working pressure at elevated temperatures. Thus, high-pressure boilers and the condensers and towers employed in certain operations connected with oil cracking and refining have to withstand a range of pressure from 29 in. of vacuum, to (say) 1,500 lb. per sq. in. (100 atm.) at temperatures from -75° F. to 1,200° F. In the petroleum industry, forge and hammer welded vessels were at one time largely used, but, according to R. K. Hopkins (*G7*), are now being replaced by fusion-welded vessels.

In dealing with pressures of 1,000 atm. and upwards it is usually not practicable to employ simple cylinders, since the stresses set up in the walls are sufficient to cause elastic failure even when alloy steels of great tensile strength are used. W. A. Bone and D. M. Newitt (*G8*) describe various types of compound cylinder in which both the tensile and compressive strength of the steel is utilised, and give details of vessels suitable for working at pressures of 15,000 atm.

Various methods for eliminating or minimising chemical attack on high-pressure plant are summarised by R. K. Hopkins (*G7*); of these, metal-spraying and chromium-plating

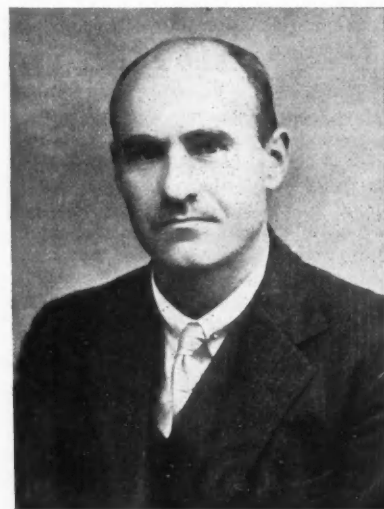
have not proved generally successful; refractory linings have been employed but require frequent renewal. An interesting development is the use of bi-metal plates, in which the base metal is a carbon steel and the facing metal a chrome or chrome-nickel steel. Up to the present it has not been possible to produce such plates of large area and heavy wall thickness, and in use some trouble has been experienced from blistering. The most satisfactory results have been obtained by the use of separate linings of 18-8 chromium-nickel steel or 12-14 per cent. chromium steel, approximately 5/64th in. thick, spot-welded to a base metal.

### Methanol Synthesis

Papers by Y. Oshima (*G5*) and T. Eguchi (*G6*) give data relative to the production of methanol from water gas in Japan; of the processes in use in that country, the one developed by Eguchi depends upon the use of a low-temperature catalyst, the working conditions being a pressure of 80 atm. and a temperature of 230° C. Attention is drawn to the effect of fluctuations of working pressure, gas velocity, and the composition of the reactants upon the yield of products. Eguchi discusses the mechanism of methanol synthesis, and supports the view put forward originally by Fischer, Tropsch and Morgan that with catalysts containing zinc oxide, zinc formate may be formed temporarily on the catalyst by the combination of CO, H<sub>2</sub>O and ZnO. At 400° C. the formate decomposes into carbonate, formaldehyde, methyl formate and methanol. The zinc carbonate thus formed will again combine with water gas to give the formate, the decomposition and regeneration being continuously repeated on the catalyst.

### Synthesis of Higher Alcohols

G. T. Morgan and R. Taylor (*G3*) find that the addition of rubidia and caesia to a methanol catalyst made from equimolecular proportions of the nitrates of manganese and chromium leads to the production of higher alcohols. It has also been observed that the addition of cobalt to various methanol catalysts (*e.g.*, basic zinc chromate) gives rise to a whole series of higher alcohols, including ethyl alcohol, although methanol is still the principal product. Morgan and Taylor have also investigated the formation of higher alcohols from lower alcohols by the use of a catalyst which acts both as a dehydrogenation and condensing agent. Experiments with ethanol, propanol and butanol produced, respectively, *n*-butanol, 2-methyl pentanol and 2-ethyl hexanol.



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W. A. Bone and D. M. Newitt (*G8*) discuss the mechanism of the slow combustion of the paraffin and aromatic hydrocarbons, and give the results of experiments with methane, ethane, benzene and toluene, at pressures up to 100 atm. In all cases the primary product was an alcohol or phenol. By a careful regulation of mixture composition and reaction temperature it was possible partially to arrest the oxidation at an early stage, and thus obtain high yields of intermediate alcohols, aldehydes and acids.

J. G. King and J. Fraser Shaw (*G4*) give a very complete account of the development of an intermediate-scale plant for the hydrogenation of tar and tar distillates at high pressures. They show that crude low-temperature tar can be treated in the vapour phase with a supported molybdenum sulphide catalyst to give a high yield of motor spirit having an octane number of 8.1. The reaction is exothermic, the heat evolved being sufficient, with adequate heat exchange and pre-heat of the reactants, to raise the feed to the reaction temperature and overcome the heat losses from the system. G. T. Morgan and J. T. Veryard (*G3*) have also investigated the products obtained by hydrogenating the solid waxes and resinoids contained in low-temperature tars.

The various types of vacuum pumps that find application in the chemical industry are classified by W. Gaede (*G1*) on the basis of the laws governing their operation. Three types are distinguished (a) the piston pump, (b) the friction pump, and (c) the diffusion pump. Of the pumps working on the piston principle, the reciprocating air pump, the rotary oil vacuum pump, the water-jet ejector and the mercury vacuum pump are described with particular reference to their spheres of application. Useful data are also given relative to pumps working on the friction and diffusion principles. Attention is drawn to the fact that high-vacuum practice is not yet highly developed in the chemical industry. For high-vacuum distillation, high-vacuum drying or dehydration and high-vacuum degasification, the mercury diffusion type of vacuum pump has been found to possess the most satisfactory properties.

### Points from the Discussion

Sir GILBERT MORGAN (Chemical Research Laboratory, Teddington) said he regarded high pressure plant merely as a means to an end. During the last ten years, a considerable amount of high pressure plant had been developed in the chemical laboratory under his supervision, but they regarded this plant only as a means of producing in a more convenient and efficient way, a chemical product which otherwise may not be so readily obtainable. Referring to the question of safety,

he said he thought the probable reason why no one wanted to raise that question was because it was rather like offering a hostage to fortune. Thirty-three members of the Congress had visited the Research Laboratory the previous afternoon, and saw some of the various safety devices in use there, and which, so far, had been successful. Although they had worked at pressures ranging from 200 to 3,000 atm., they had not yet had an accident, largely because they had regarded the golden rule of Sir Richard Threlfall, who used to say that the only way to deal with high pressure plant was to recognise that if they used it long enough, sooner or later it was going to blow up.

In giving some details of the safety measures adopted at his laboratory, Sir Gilbert went on to say that all the autoclaves were surrounded by  $\frac{1}{2}$  inch thick steel framework and they also had mantles such as were used in their cordite factories; therefore they had a double protection in case of an accident resulting from some fracture in some part of the apparatus. All their plant was home-constructed, and he thought the fact that they had gone for something like 11 years without any serious trouble was a great tribute to their staff.

Referring to the experiments carried out by Mr. Taylor with ethyl alcohol and its conversion to a higher alcohol, Sir Gilbert went on to say that when they first started this work at Teddington, literature on the subject was very scanty.

Dr. J. A. KING, in dealing with the problems faced by chemical engineers in studying the reactions which took place in plant, said they were faced with the difficulty of providing a set of conditions whereby a reaction could be carried on without damage to the plant. Starting with mild steel, in a small scale plant, they found that there were considerable corrosion effects and also chemical effects caused by the action of hydrogen at high temperature upon steel. The normal structure of mild steel was so altered and weakened that in at least one case, the experiment ended in the disruption of the plant. They found it was possible to overcome the corrosion effect by introducing pipe lines of special steel as described in the paper, but there was still a surplus of corrosion, which, if the plant was cooled down at frequent intervals, may cause splitting up, due to the inequality of expansion.

Mr. KOLBECK (I.C.I.) advised members never to sacrifice conductivity for high tensile strength. There had been indications in the United States, he said, that workers in the high pressure field had gone after forgings with very high tensile strength indeed, actually making use in some cases of tool steels. He felt sure that that must be wrong.

## Heat Exchange—Section H

By B. HEASTIE

*H1.* The Concentration by Evaporation of Solutions Liable to be Affected by High Temperatures. (Austria.) By W. Vogelbusch. *H2.* Questions of Heat Transference in the Chemical Industry. (Germany.) By S. Erk. *H3.* Heat Transmission—Some Recent Advances. (Gt. Britain.) By C. H. Lander, M. Fishenden and O. A. Saunders. *H4.* Heat Transfer Coefficients for Water and Steam in a Surface Condenser. (Gt. Britain.) By R. M. Ferguson and J. C. Oakden. *H5.* A New Method of Evaporation Operating at Low Temperature with Waste Heat. (Sweden.) By H. Elis E. Göth. *H6.* A New Method of Waste-heat Recovery from Intermittent Sources, such as Gases and Vapours in the Chemical Industry. (Sweden.) By C. Rosenblad. *H7.* Heat Transmission. (United States.) By T. B. Drew, H. C. Hottel and W. H. McAdams. *H8.* Induction Heating in the Chemical Industry. (United States.) By C. E. Daniels. *H9.* Condensation of Vapours Admixed with Gases. (France.) By M. Rouilly.

### Vapour Recompression Evaporator

W. Vogelbusch (*H1*) deals with a clever adaptation of the vapour recompression evaporator, in which the whole of the vapour driven off by evaporation is taken to the recompressor and delivered to the evaporator; part is condensed in transmitting heat to the boiling liquid, the remainder is passed to the condenser at the temperature of the steam-vapour mixture,

which may be 20° C. higher than that of the boiling liquid. In this system the exit temperature of the cooling water is a



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few °C. below that of the operating steam, whilst in the older recompression system the exit temperature is a few °C. below the vapour temperature above the boiling liquid.

One great disadvantage of the recompression system is the small temperature difference from the steam to liquid side, which is further reduced by the presence of incondensable gases. In the author's design, however, special means are adopted to remove these gases without the necessity of venting during operation, usually a source of considerable loss of steam.

### Heat Transfer

Curves of the temperature and velocity distribution of air flowing at right-angles to a circular tube are given by S. Erk (*H2*). Radiation from non-luminous gases is treated in detail by C. H. Lander, M. Fishenden and O. A. Saunders (*H3*), and some experimental results are given for water vapour and carbon dioxide over a range of 1,000 to 2,000° F. R. M. Ferguson and J. C. Oakden (*H4*) deal very fully with the heat-transfer coefficients from the steam to tube, and tube to water, in a surface condenser. The coefficient for heat flow from the tube to water is based on the hypothesis that there is an intermediate layer between the turbulent core and the viscous film in contact with the tube.

The utilisation of heat from waste flue gases has occupied the minds of countless chemical and power-plant engineers, but of the many schemes proposed, few have been a commercial success. Among the difficulties met with are the following:—(a) The low available heat-content of the gas, e.g., 1 kilo of gas cooling 100° C., would give out about 24 calories, or about 22 kilos of flue gas would be required to evaporate 1 kilo of water; (b) the heat transfer from a gas to a metal wall, even at high velocities, is extremely small, thus necessitating large heating surfaces for even small outputs; (c) in order to obtain high velocities, forced draught is necessary, requiring fans of large capacity; (d) fouling of the passages through the heater, due to deposits from the flue gas; (e) rapid corrosion of the metal used in construction if the flue gases are cooled below their dew-point, especially where the fuel used has a high sulphur-content. The plant described by H. Elis E. Göth (*H5*) is very interesting, and as it is in actual operation, no doubt some of these difficulties have been overcome—to drive the fans, how often the heater plates require cleaning, and of what material the bubbler is constructed, as, if mild steel is used, we would have expected very rapid corrosion, due to dissolved oxygen in the liquid.

C. Rosenblad (*H6*) describes the use of the heat accumulator for the storage and recovery of heat from the intermittent blowdown of digesters in the sulphate pulp industry. This is made possible by the use of a heat exchanger having spiral passages, for which very high heat-transfer coefficients are claimed. Plate-type heat exchangers having spiral passages were proposed some years ago by a British manufacturer, but were superseded by the rectangular-plate "filter-press" type, as the latter were simpler in construction and presented less manufacturing difficulties, although the pressure-drop, due to the sudden change in direction of flow, would be greater than in the spiral type.

T. B. Drew, H. C. Hottel and W. H. McAdams (*H7*) have given a very extensive survey of our present knowledge of heat transfer. It is essentially practical, and should be of great use to the designer. The condensation of vapours is ably dealt with, covering the use of contaminants to produce drop-wise condensation of the steam. In the section devoted to optimum velocity, an attempt is made to determine this mathematically, making certain cost assumptions.

### Induction Heating

The application of inductive heating in process industries is relatively recent, states C. E. Daniels (*H8*); heating, however, has been used for many years, but its high cost has prevented its extended use. One of the earliest applications of inductive heating was for melting steel, in which the metal formed a closed circuit in which enormous currents were

generated. A very good way of conveying heat at temperatures up to 300° C. is by using a secondary fluid, e.g., oil, or diphenyl, which is heated electrically and circulated round the jacket of the vessel to be heated. By this means the temperature is under control.

M. Rouilly (*H9*) deals with the separation of gases and vapours by ordinary refrigeration. The author describes a heat exchanger of special construction employing gilled tubes.

### Points from the Discussion

Mr. HUGH GRIFFITHS, who opened the discussion, said an important point had not been made clear, and that was that in the normal system, the steam consumption would be only about one half of that required by the Vogelbusch system.

Mr. W. F. CAREY (I.C.I.) drew attention to the economies which should result from analysing the performance of actual working coolers in the light of the large body of theoretical work which was now available.

Dr. H. D. H. DRANE (Liverpool), in a reference to the paper on induction heating, said he appreciated the attractiveness of this method of heating, but it seemed to him that there were certain objections which should be considered. For one thing, he rather thought that in this country the cost of the necessary productive arrangements would be prohibitive.

Dr. MARGARET FISHENDEN (Imperial College of Science and Technology) referred to the paper on heat transmission, and said that Hottel's work seemed to have been very carefully carried out and far the most extensive in range. She felt that undoubtedly the next step was to try and apply this attitude to industrial problems. In this, she was in agreement with the attitude of Erk, who pointed out that it was not only by faith in fundamental principles, but by continuous and concentrated efforts to apply these principles that progress would be made.

Mr. SAUNDERS said it was gratifying to see the increased attention being paid to the subject of heat transmission, not only to its practical aims, but as a scientific problem.

Professor W. G. WHITMAN (Massachusetts Institute of Technology) contended that it was necessary that they should push the industrial application of this work as much as possible.

Dr. KIESSKALT referred to the process utilising oil combined with steam and said it had been found that the increase in heat transfer coefficient from 15 to 30 could be secured in this way. He found, however, that more difficulties would be found in applying this process because chemical changes occurred in the later stages which gave rise to difficulties.

Dr. A. F. BURSTALL said he thought there was an urgent need for getting a clearer physical conception of how heat transference actually took place. At present it was not at all clear.

Mr. K. FRASER said the point they had been faced with in the design and manufacture of heat exchange apparatus was that of a change of phase. Actual heat transmission data was extremely difficult to obtain in practice because they could not definitely say at what particular stage the heat transfer phase actually took place.

## Far Eastern Chemical Notes

PURE ANTHRACENE AND CARBAZOLE are now made by Nippon Seitetsu K.K.

THE SUM OF 500,000 YEN HAS BEEN SET APART by the Nippon Seitetsu K.K. for development work in high pressure coal hydrogenation.

EXTENSIONS TO THE SYNTHETIC NITRIC ACID PLANT of Yahagi Kogyo K.K. are now completed, thus increasing the daily output from 10 to 20 tons.

THE HOKKAI SODA K.K. is planning to increase its range of products by embarking upon the manufacture of trichlorethylene, ferrous and ferric chlorides, chlorinated rubber, tetralin and ammonium perchlorate.

## The Institution of Chemical Engineers

### Overseas Guests at the Annual Dinner

**T**WENTY-ONE countries outside the British Empire and five within the Empire were represented among the 400 guests at the fourteenth annual dinner of the Institution of Chemical Engineers, held at the Hotel Victoria, London, on Tuesday evening, under the presidency of Dr. Herbert Levinstein. Capt. D. Euan Wallace, Secretary of the Department of Overseas Trade, was the principal official guest, and there was a large attendance of members of the American Institute of Chemical Engineers, who had arranged their visit to this country to coincide with the Chemical Engineering Congress.

Captain D. EUAN WALLACE, in proposing the toast of the Institution, said few people would deny to-day that it was desirable, and many would assert that it was essential, that in most fields of economic activity, wasteful competition should be replaced by intelligent co-operation. This process would, if it was upon a large scale, usually involve the State; it might be to provide financial assistance; to enact legislation or to help in one or more of a variety of other directions. Generally speaking the Government would have to be at least an accessory before the fact when any general advance was contemplated. For this reason the importance of a close liaison between the State and industry could scarcely be over-emphasised; and the fact that they had entrusted the toast of the Institution to a member of the Government was, he hoped, a proof that they shared that view.

#### The Work of the Chemist

Chemical manufacture had penetrated into almost every part of our lives. Our clothes were made to last by dyes and bleaching agents; our newspapers were a triumph of chemistry both as regards the printing and the paper; we ate without anxiety because chemistry had assisted in the production of hygienic heating and cooking utensils, of fresh fruit free from insects and of tinned food kept safe from toxic elements. Our drinks were chemical products in themselves. In sport we relied on chemical manufacture for the production of much of our equipment, whether it was a golf ball, a tennis racquet, a cricket bat, a football or a cartridge. At the theatre or the cinema the same thing applied; the players' make-up in the former was just as much an example of chemical manufacture as the film itself in the latter. The whole of our machinery was kept in motion by lubricants which were also the products of this same union of the engineer and the chemist.

For all those additions to the safety and enjoyment of life which were due to chemical manufacture, the credit must go in the first place to the laboratory and research chemists. But the practical results of their work in the form in which we could make use of it was only available through the work of the chemical engineer. Discoveries in chemistry as in other allied fields could seldom be given a commercial application until the efforts of the engineer had been called in to supplement the pioneer work of research.

#### Congress and Exhibition

The dinner coincided with the holding for the first time of an international congress in London at which the leading chemical engineers of the world were discussing the latest advances in technique for the operation of many kinds of industrial plant. He felt confident that the importance of the United Kingdom's contributions to these discussions would reflect the eminent position which our chemical engineers at present occupied. The Congress was an offspring of the World Power Conference, and the holding of it showed that the engineering world was now fully alive to the great importance of the chemical branch, and that the chemical engineer was receiving a measure of recognition commensurate with his qualifications and the great and growing importance

of his work. Simultaneously with the Congress, United Kingdom manufacturers of equipment designed by our chemical engineers were through the British Chemical Plant Manufacturers' Association demonstrating to overseas visitors the various classes of up-to-date plant that could be purchased from this country, in which they believed that economical production was allied to long life and high efficiency to an extent unobtainable elsewhere.

At a time when chemical engineering was in such a state of development the work of the Institution in promoting its theory and practice, and safeguarding the general welfare of the chemical engineer was of the utmost importance. The Institution acted as a qualifying body for the profession; it was continuously improving educational facilities and disseminating knowledge of the fundamental principles of chemical engineering and of advances made in technique; and its transactions had won for themselves an established place in scientific literature. The Department of Overseas Trade co-operated with the Institution two years ago in an attempt to make those transactions more widely known among students of the leading universities and technological colleges in a number of foreign countries. The Government had tried to create conditions favourable to industrial expansion, and although they had no cause to be complacent (no one ever had) a considerable measure of success had been achieved.

#### Improved Economic Conditions

For the past six months each successive figure of the number of our insured workpeople in whole-time employment had created a fresh record; our exports of manufactured articles rose in value by more than £24,000,000 in 1935, compared with 1934 and there had been a steady increase throughout the first five months of this year compared with the corresponding period of 1935. The creation of favourable conditions was only half the battle in a highly competitive world, when the major economic problem appeared to-day to be that of consumption rather than production. To increase an already great export in face of difficulties unknown at the height of our industrial prosperity, required not only skilful salesmanship but the enlightened application of the work going on continuously day by day in our chemical laboratories. We had got to produce an article which would sell not only because of its quality but because of its competitive price.

The chemical engineer provided the skill by which the work of research, investigation and experiment was converted into plant or products which were sold in the markets of the world. The chemical engineer could make a substantial contribution to the maintenance of our high level as a manufacturing and exporting nation, and he felt sure that the members of the Institution would, with pride in their achievements of the past, add even greater lustre to a great profession by their achievements in the years to come.

#### The President's Response

The PRESIDENT, in responding to the toast, said the Institution warmly welcomed the presence of so many distinguished colleagues from every part of the world. He referred particularly to the members of the American Institute of Chemical Engineers, to which the Institution was allied by many ties of friendship and hospitality, and to the many ladies who had accompanied the overseas visitors. Every chemical engineer, he said, was striving to produce something new, and he was constrained to ask himself whether a great deal of the trouble we had in this world was due to the fact that those engaged in research had come into an old world that was unprepared to receive such blessings as they had to offer.

Dr. W. R. HALLIDAY, Principal of King's College, London, proposed the toast of the Chemical Engineering Congress.

The Congress, he said, emphasised the fact that despite the distinctions that existed in other realms, science knew no national boundaries. In such gatherings those who were interested in the same problems had the chance of seeing in the flesh the men of whose work they had known for some time. Even more important than the pooling of ideas were the friendships which were made on such occasions. He coupled with the toast the name of Lord Leverhulme, president of the Congress, to whom, next to the late Sir Frederic Nathan, the Congress largely owed its origin. Lord Leverhulme was the industrious but unduly modest son of a great father, a great captain of industry and one who, like his father, had given practical evidence of personal interest in the advancement of human knowledge and in the practice and appreciation of the arts.

#### Eight Hundred Delegates

LORD LEVERHULME, in responding to the toast, said he had to speak on behalf of some 800 delegates attending the Congress, of whom about 450 were from Great Britain and 350 from overseas, representing over thirty countries. The problems of the chemical engineer were the same in every country, and they were convinced that the Congress was helping to break down national barriers. This was the first international congress of chemical engineering, and its success would determine whether other similar international congresses were to follow. Perhaps in the future other countries would offer hospitality to the chemical engineers of the world, but Great Britain would always be proud of having been the host for the first congress, and the Institution of Chemical Engineers would value very much the opportunity it had had of being the body primarily responsible for bringing the congress into being. It would take an average speaker a great deal of time to define chemical engineering, but Sir Harold Hartley, in a broadcast talk on Monday evening, had summed it up in five minutes for the benefit of the countless thousands of people who were listening in.

#### Recipients of Birthday Honours

DR. WILLIAM CULLEN, vice-president, proposed the toast of the guests. Referring to the King's birthday honours, he offered congratulations to Captain Euan Wallace upon his appointment as a member of the Privy Council, Professor G. T. Morgan upon receiving a knighthood, and Mr. G. S. Whitham, of the War Office, who had received the C.B.E. He also referred to the knighthood conferred upon Mr. James Morton for his services to the dyestuffs industry, and to the C.B. conferred upon Dr. G. Rotter, of the Research Department at Woolwich. It was a pleasure to the Institution to see Professor H. E. Armstrong amongst the guests. Referring to the American Institute of Chemical Engineers, Dr. Cullen said the members of that Institute came to Great Britain in 1924 and entertained the Institution when its members visited the United States in 1928. They were to have come again in 1932, but the economic crisis had caused the postponement of their visit until this year.

#### A Monopoly of Ideas

MR. MARTIN H. ITTNER, president of the American Institute of Chemical Engineers, in reply, said the good feeling engendered by the Congress was of great value to them all. Important as were the papers that were being presented at Westminster, the contacts and friendships created by the gatherings were of even greater value. No country had a monopoly of chemical engineering ideas or their application. Great accomplishments had materialised in the different countries represented among the guests, and it was well that they should look beyond their own horizon and study the discoveries which others had made.

Engineer Vice-Admiral Sir HAROLD BROWN, engineer-in-chief of the Fleet, also responded to the toast.

MR. H. W. CREMER, hon. secretary, proposed the toast of the president, to which Dr. LEVINSTEIN briefly replied.

## W. J. Bush and Co., Ltd.

### Creation of New Reserve Fund for Plant

PRESIDING at the 39th annual general meeting of W. J. Bush and Co., Ltd., in London, on June 22, Mr. J. M. Bush (chairman and one of the managing directors) said the policy of the Government, as the result of the report of the committee appointed by the Board of Trade, to which he referred at the last meeting of the company, in recommending Parliament to extend the Key Industry Duties for another 10 years, encouraged them to feel that the large expenditure of capital they have incurred in past years on plant and machinery will not have been in vain. On the other hand, there are signs of increasing competition in some of the most important chemicals we manufacture, and the numerous obstacles in the way of carrying on export business in foreign countries still remain.

New processes for the manufacture of organic chemicals are constantly being devised, continued Mr. Bush. Their own research chemists are also continually working with a view to initiating new or improving existing processes of manufacture, increasing yields and cutting down costs. Such changes sometimes necessitate considerable modifications of the plant or the installation of completely fresh units rendering the old obsolescent. It is for this reason that the directors recommend the creation of a reserve against this contingency.

## Congress Items I

THERE WAS A DISTINGUISHED GATHERING of delegates and their friends in the ballroom of the Dorchester Hotel, Park Lane, on Monday, for the first evening function. Lord Leverhulme, president of the Congress, received the guests, and in spite of the tropical weather conditions prevailing at the time an excellent programme of dancing was thoroughly enjoyed until the early hours of the morning.

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HIS MAJESTY'S GOVERNMENT held a reception on Wednesday evening at Lancaster House, St. James's, in honour of the Chemical Engineering Congress. The Lord President of the Council and Miss MacDonald received some 300 guests. The band of the Grenadier Guards played during the evening. Among those who accepted invitations were the Austrian Minister, the Danish Minister and Countess Ahlefeldt-Laurvig, the Dominican Minister and Madame Henriquez-Urena, the Estonian Minister and Madame Schmidt, the Hungarian Minister and Madame de Masirevich and Mademoiselle de Masirevich, the Norwegian Minister and Madame Colban, the German Chargé d'Affaires and Princess Bismarck, and the Japanese Chargé d'Affaires.

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MONSIEUR A. BARIL, president of the International Gas Union, was the principal guest at the dinner given at Grosvenor House, on Monday, by the Institution of Gas Engineers. Among those present at the dinner, which was held in honour of the gas delegates to the Chemical Engineering Congress of the World Power Conference, were:—Herr Fritz Escher (Switzerland), hon. president, International Gas Union, Herr H. Ellis A. Goth, secretary, Swedish Gas Association, Herr G. H. Haultman, president, Swedish Gas Association, Dr. F. van Oostrom Meyjes (Holland), M. Pierre Moujin, general secretary, International Gas Union, Dr. Hermann Muller (Germany), Herr F. zur Nedden, managing director, German Association of Gas and Water Engineers, Ing. Dr. F. Perna (Czecho-Slovakia), Professor Dr. Paul Schlapfer (Switzerland), Lieut.-Col. G. E. H. Zollikofer, secretary, Swiss Society of Gas and Water Engineers, Mr. Stephen Lacey, president of the Institution of Gas Engineers, Mr. Robert Roberts, vice-president, and Mr. J. R. W. Alexander, secreta



## Personal Notes

Mr. C. F. HILL has been appointed a director of Goodlass Wall and Lead Industries, Ltd.

Mr. JAMES FRANCIS HALPIN, late Superintending Chemist, Government Laboratory, London, died on June 21, following an operation, aged 69.

Mr. THOMAS FIRTH, of Sorrento, Lower Warberry Road, Torquay, Devon, formerly a director of Thomas Firth and Sons, Ltd. (now merged in Thomas Firth and John Brown, Ltd.), left gross estate valued at £76,669.

INCLUDED in the list of promotions recently sanctioned by the King in the Venerable Order of the Hospital of St. John of Jerusalem is the name of Mr. F. W. Clifford, who is promoted as Officer from the grade of Serving Brother. Mr. Clifford is the librarian of the Chemical Society, but in his spare time has been actively engaged in ambulance matters for many years. He possesses the long service medal and bar, and was one of those selected to receive the late King's Jubilee Medal. For the past 12 years he has been a staff officer in No. 1 District.

Professor J. S. HALDANE, of Cherwell, Oxford, left personal estate in Great Britain valued at £54,430.

Dr. LESLIE BURGIN left a nursing home on Tuesday so that he could attend to urgent and important work connected with his office. He is to return to the nursing home within a fortnight to undergo an operation.

Dr. W. V. MAYNEORD has been appointed as from July 1, 1936, to the London University Readership in Physics tenable at the Royal Cancer Hospital (free). Since 1927 he has been physicist to the radiological department of the hospital, and since 1936 he has also been acting head of the physics department.

Dr. C. J. B. CLEWS and Mr. KENNETH STEWART have been awarded University of London postgraduate travelling studentships of the value of £275 for one year. Dr. Clews proposes to do further research in X-rays under the direction of Professor K. M. G. Siegbahn at the University of Upsala, and Mr. Stewart intends to study the chemical reactions in the electric discharge under Professor Harteck at Hamburg.

## King's Birthday Honours

### Professor G. T. Morgan becomes a Knight

SCIENCE is recognised in the King's Birthday Honours List, issued on Tuesday, the first of the reign of Edward VIII, by the knighthood conferred upon Professor GILBERT THOMAS MORGAN, O.B.E., D.Sc., LL.D., F.I.C., F.R.S., director of the Chemical Research Department of the Department of

Scientific and Industrial Research. Professor Morgan has been director of the Chemical Research Laboratory at Teddington since 1925. He is a former president and secretary of the Chemical Society and a member of the committee appointed by the Board of Trade to advise on the development of the dye-making industry. A knighthood has also been conferred on Dr. JAMES MORTON, for services to the dye and colour industries. Dr. Morton



Sir Gilbert T. Morgan.

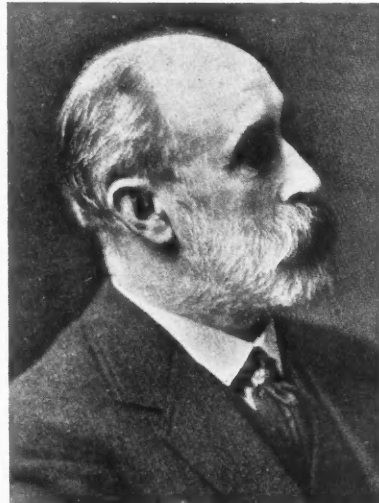
is chairman of Morton Sundour Fabrics, Ltd., and of Standfast Dyers and Printers, Ltd., and was a founder of Scottish Dyes, Ltd., now incorporated in Imperial Chemical Industries, Ltd. He was awarded the Faraday Centennial Medal in recognition of his work in developing and extending the manufacture of anthracene dyestuffs and in extending their application to silk and wool.

Other honours include: Alderman HARRY SPEAKMAN, J.P. (Knight Bachelor), for political and public services in Leigh, Lancashire. Alderman Speakman was formerly chairman and one of the original founders of Sutcliffe, Speakman and Co., Ltd., of Leigh. He is a past president of the Manchester Geological and Mining Society. Mr. FREDERICK JOSEPH WEST, C.B.E., M.Inst.C.E., M.I.Mech.E., J.P. (Knight

Bachelor), for public services in Manchester. Mr. West is chairman and managing director of West's Gas Improvement Co., Ltd. He was president of the Manchester Engineering Employers' Association in 1916 and 1917, and is a past president of the Manchester Association of Engineers, a past

chairman of the Society of British Gas Industries, and a past president of the Manchester Chamber of Commerce. Dr. CEDRIC STANTON HICKS (Knight, Dominions), Professor of Human Physiology and Pharmacology at the University of Adelaide, South Australia, for services to medical education. Mr. GILBERT SHAW WHITHAM, M.I.Chem.E. (C.B.E., Civil), assistant director of ordnance factories, War Office. Mr. JOHN RUTHERFORD HILL (O.B.E.,

Civil), resident secretary in Scotland of the Pharmaceutical Society of Great Britain. Mr. GEORGE ERNEST BAILEY (M.B.E., Civil), accountant, National Physical Laboratory, Department of Scientific and Industrial Research. Mr. PERCIVAL GEORGE LLOYD (M.B.E., Civil), chemist and manager, Borough Sewer Works Department, Kingston-on-Thames. Mr. FREDERICK HENRY NEWINGTON, F.I.C. (M.B.E., Civil), assistant analyst, Admiralty Chemists' Department, Portsmouth. Dr. GODFREY ROTTER, C.B.E., D.Sc., F.I.C., F.Inst.P. (C.B.), director, Explosives Research Branch, Research Department, Royal Arsenal, Woolwich. Mr. W. THOMAS MUNRO (C.B.E.), of Munro and Co., Ltd., Edinburgh. Of the new peers, Sir HERBERT AUSTIN recently gave a princely benefaction to Cavendish Laboratory at Cambridge.



Sir James Morton.

## Continental Chemical Notes

### France

ACTIVE CARBON MANUFACTURE is principally in the hands of the Société Carbonisation et Charbons Actif (annual production 4,000 tons) and the Société des Produits Organochimiques (annual production only 300 tons).

### Hungary

PLANS FOR THE ESTABLISHMENT of a Hungarian film base industry have been recently discussed, and it is now understood that the Filmbank A.C. and the Gerő Film Company will participate in forming the Hungaria Rohfilm A.G., with a capital of 0.3 million pengos.

### Sweden

A NEW HIGH RECORD IN SULPHITE SPIRIT PRODUCTION was reached in 1935 at 255,000 hectolitres, over one-half of which was used in blended motor spirit.

PATENTS RELATING TO A NEW TYPE of match which can be repeatedly ignited are understood to have been acquired by the Swedish Match Trust. It is based upon a low-temperature ignitable head (consisting of an organic substance such as metaldehyde or a mixture of paraldehyde with hexamethylene-tetramine or other base) coated with an ignition layer of the more usual type containing about 60 per cent. potassium chlorate.

### Germany

MANUFACTURE OF LUBRICANTS FROM GERMAN PETROLEUM is to be undertaken by the "Nerag" concern, recently formed at Hanover under participation of the Preussag and Elwerath concerns.

PRODUCTION OF AMBER PRODUCTS during 1935 was on a higher level than during 1933 or 1934, states the trading report of the Preussische Berwerks- und Hütten-A.-G. Output figures (in kilos) are declared at 103,000 crude amber, 4,000 pressed amber, 103,000 fused amber, 35,000 amber oil and 2,350 succinic acid.

EVIDENCE OF INCREASED ACTIVITY in the wood saccharification industry is provided by two recent company formations: The Brunswick Wood Saccharification Company W. Grottrian-Steinweg and the Bergius Construction Company. With a capital of 600,000 marks the latter concern proposes to design and construct plant with particular reference to the working-up of wood and like raw materials by the Bergius hydrolysis process.

### Estonia

REFERENCE WAS MADE in this column on May 2 to oil shale production in Estonia, and the impression was created that Eesti Kivioli a/ü (Estnische Steinöl A.-G.) had had an unfavourable business year in 1935 followed by corresponding deductions. In 1935, as in previous years, the firm worked with a completely satisfactory result showing a profit within the limits of preceding years. These results were achieved in spite of a comparatively small production, about 25,000 tons. This year, however, the capacity of the works will be enlarged by way of building a new plant almost three times as big as before, in order to make use of a new market for oil. For the extension of the works considerable fresh money is being raised. The balance sheet of the firm has undergone a radical clear up and considerable expenses incurred in former years in connection with testing of the oil producing process have been completely written off. At the same time a reduction of the share capital has taken place. However, in order to obtain a correct view on the position, attention must be drawn to the fact that the reduced capital has again been filled up and increased from the original Kr. 600,000 to Kr. 1,200,000.

### Russia

THE FIRST CENTRAL ASIAN OIL REFINERY has reached completion in the "Nephtedagskaja Gora" field, with a daily throughput of 700 tons of crude oil.

IN CONNECTION WITH THE PROPOSED CHANGE-OVER of Russian blast furnaces to the oxygen blast process, work has been commenced at the Kirow Metallurgical Works upon the construction of an oxygen plant with a daily capacity of 20,000 cubic metres oxygen.

### Italy

SAMPLES OF PRODUCTS based upon polymerised butadiene synthetic rubber were recently exhibited at the Milan Fair by the Pirelli Co. The primary material for this type of rubber is acetylene which is oxidised to acetaldehyde and the latter condensed with ethyl alcohol. By a dehydration reaction this condensation product yields butadiene.

REPORTS CONCERNING LANITAL (CASEIN WOOL) PRODUCTION on a considerable scale have been exaggerated, the present output of the Snia Viscosa only amounting to 2 tons per day, while an increase to the moderate daily level of 20 tons is not anticipated before next year. This would represent one-tenth of Italy's natural wool consumption.

PERMITS HAVE BEEN GRANTED by the Ministry of Corporations in respect of new developments to the following firms: S. A. Vernici and Smalti Arenzano, Geneva (bleached shellac plant); S. A. Esercizio Forni Elettrici, Milan (a calcium cyanamide plant with maximum annual capacity of 7,500 tons); "Montecatini" Soc. Gen. per l'Industria Mineraria, Milan (factory for glyceryl phthalate resins); Soc. Italiana Ebonite and Sostituti, Milan (factory for phenol-formaldehyde resins).

## Dinner to Professor W. A. Bone

### Presentation on Occasion of Retirement

PROFESSOR W. A. BONE was the guest of honour at a dinner given by the Department of Chemical Technology of the Imperial College of Science and Technology on June 17. The chair was taken by the Rector of the College, Mr. H. T. Tizard, C.B., F.R.S., and a distinguished gathering, including many old colleagues and students, assembled to pay tribute to the Professor on the occasion of his retirement.

Professor G. I. FINCH, O.B.E., in proposing the health of Professor Bone, presented him with a gift of silver plate on behalf of his colleagues, and past and present students.

Professor H. E. ARMSTRONG, F.R.S., spoke of the significance of Professor Bone's contributions to the theory of combustion; he had followed his career from his early days in Manchester up to the present time, and regarded him as a great experimentalist, whose work was based upon facts established on crucial experiments, unfettered by hypothesis and inclination.

Sir DAVID MILNE-WATSON, governor of the Gas Light and Coke Co., gave an appreciation of Professor Bone's services in relation to the gas industry.

Other speakers included Dr. H. Levinstein (president of the Institution of Chemical Engineers), Dr. Harold Hartley, Dr. Haffner, Mr. W. E. King and Professor J. Philip, F.R.S. Messages were read from Sir Wm. Bragg (president of the Royal Society), Sir John Russell, Sir Robert Robertson, Dr. Charles Carpenter, Sir Wm. Larke, Sir Frank Smith, Dr. Sinnatt and Professor Wheeler.

Professor Bone's retirement does not mean the ending of his scientific activities, for the college authorities, strongly supported by industry and other outside bodies, are providing a new research laboratory in which he will be enabled to pursue those researches on which he is still actively engaged.

## From Week to Week

BOOTS PURE DRUG CO., LTD., has contributed £525 to the King George Memorial Fund.

THE NATIONAL COKE AND OIL CO., it is reported, has placed an order with France Fenwick Tyne and Wear Co., Newcastle, for 50,000 tons of non-caking coal to be delivered during the next six months to its coal distillation plant at Erith, Kent.

PLANS TO DRILL FOR OIL in the shale region of the Lothians are being considered by the Anglo-Iranian Oil Co., Ltd., who have undertaken a preliminary geological survey. The Lothians is the only Scottish area scheduled for prospecting so far, as it is thought most likely to produce oil in marketable quantities.

A FIVE-TON LORRY, fully laden, has just made a 100 miles' journey from Leicestershire to London on "solid petrol" made from coal at the works of British Coal Distillation, Ltd., at Newbold, Leicestershire. The saving on fuel was claimed to be 60 per cent. "Solid petrol," which is produced by distillation, looks like small pieces of burnt coal.

DAMAGE ESTIMATED TO AMOUNT to £8,000 or £10,000 was caused by a fire on June 20, at the extensive factory of William Forrest and Son (Paisley), Ltd., glue, tallow and grease manufacturers, Fulbar Road, Paisley. The outbreak originated in the top flat of a four-storey building used as a tannery and store, which contained a very large stock of albumen, varnish and barrels of grease. To get at the seat of the fire the firemen utilised the fire escape as a water tower to pour water in on the building.

A CLEVER PIECE of engineering work in connection with the factory extensions for Boots Pure Drug Co., Ltd., at Beeston, was successfully carried out over last week-end, the steel girders for the new bridge over the canal being "floated" into position on Saturday morning and the erection completed during the afternoon. The work is being carried out by Redpath, Brown and Co., of Manchester, to the design and under the supervision of Boots' chief engineer.

CONTRACTS TO THE VALUE of £150,000 have been placed by Low Temperature Carbonisation, Ltd., for new plant to be erected at Bolsover in connection with the conversion of 6,000,000 tons of coal into oil, fuel and petrol. The contractors are Simon-Carves, Ltd., of Cheadle Heath, Stockport; Babcock and Wilcox, Ltd., Renfrew; Naylor Brothers, Ltd., Park Iron Works, Sheffield; Qualter Hall and Co., Ltd., Barnsley; E. J. and J. Pearson, Ltd., Stourbridge; and the Horsehay Co., Ltd., Wellington, Salop.

THE LONDON OFFICE of the United Steel Companies, Ltd., will be moved on Monday next to 8 and 10 Grosvenor Gardens, S.W.1. (Telephone: Sloane 4833). The office represents the following branches and associate companies: Steel, Peech and Tozer, Sheffield; Samuel Fox and Co., Ltd., Sheffield; United Strip and Bar Mills, Sheffield; Appleby-Frodingham Steel Co., Ltd., Scunthorpe; Daniel Doncaster and Sons, Ltd., Sheffield; Workington Iron and Steel Co., Workington; The Rothervale Collieries, Treeton; United Coke and Chemicals Co., Ltd., Workington; Thos. Butlin and Co. branch, Wellingborough.

IN THE COURT OF APPEAL, on June 20, before Lords Justices Slesser and Romer and Mr. Justice Eve, an appeal was brought by the National Carbonising Co., Ltd., from a decision of Mr. Justice Clauson in the Chancery Division, dismissing their action against British Coal Distillation, Ltd. In the action, the plaintiffs asked for a declaration that they were entitled to receive from the defendants full particulars of any improvements and further inventions in respect of the L. and N. coal distillation process as and when the defendants became entitled to them, and that the plaintiffs were entitled to use and work these improvements and inventions as provided by a clause in a licence dated July 28, 1931.

A PROPOSED SCHEME of CAPITAL REORGANISATION is explained in a circular to shareholders of Lafarge Aluminous Cement Co., Ltd. The effect of the scheme would be that the 17,000 £1 preferred ordinary shares and 260,000 1s. preferred shares would be converted into a single class of 120,000 5s. ordinary shares. Present holders of these two classes of shares would give up 40,000 ordinary shares to be distributed among holders of preference shares. The latter are asked to agree to the cancellation of arrears of preferential dividend and of their right to receive (a) 20 per cent. of any ultimate dividends paid after a 7 per cent. dividend has been paid on the other shares, and (b) 20 per cent. of any ultimate surplus of assets in a winding-up after the capital of the other shares has been paid. An extraordinary general meeting is to be held on July 16 for consideration of the necessary resolution.

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MANY NEW LARGE DEPOSITS OF FULLER'S EARTH, it is reported, have been discovered in Soviet Georgia.

THE NAME OF BRITISH CYANIDES CO., LTD., 1 Argyll Street, London, W.1, was changed to British Industrial Plastics, Ltd., on June 15.

THE LONDON AND NORTH-EASTERN RAILWAY COMPANY has placed orders for the delivery of 125,000 gals. each of creosote oil with the Scottish Tar Distillers, Ltd., Falkirk, and Summers and Co., Glasgow.

BRITISH PLASTER BOARD, LTD., announces that an extraordinary general meeting will be held at Brettenham House, Lancaster Place, London, W.C.2, on July 14, following the ordinary general meeting, when a resolution will be proposed for the revision of the articles.

THE BRITISH SUGAR CORPORATION, LTD., was incorporated last week, with a nominal capital of £5,000,000, for the purpose of amalgamating fifteen beet sugar manufacturing companies, under the provisions of the Sugar Industry (Reorganisations) Act. The companies are to be liquidated, and shareholders will be asked to approve the payment of compensation to directors for loss of office.

A SAMPLE OF THE FIRST product of the benzole produced in the plant installed at Salford Gas Works was shown to members of the Light, Heat and Power Committee of the Corporation at their meeting on June 22. The plant was installed as part of the reconstruction of the gas undertaking. Its output is to be sold to spirit manufacturers, and an additional source of revenue has been created which, in time, may lead to a reduction in the price of gas after the debt on the undertaking has been wiped out.

NEW ZEALAND LOCAL AUTHORITIES have placed new orders for manufactures, totalling £23,500 in value, with British firms. The contracts include £2,000 worth of chemicals from Liverpool and St. Helens manufacturers, for the New Zealand Fruitgrowers' Federation. New Zealand's purchases of British iron and steel, electrical goods and chemicals during the first five months of 1936 totalled £1,250,000, an increase of £240,000 or 24 per cent. over the same period of last year.

THE BOARD OF IMPERIAL CHEMICAL INDUSTRIES has issued a circular referring to statements made on behalf of the Deferred Shareholders' Committee, which has opposed the capital scheme approved by the court in November, 1935. The board has decided, says the circular, that if by any chance the appeal to the House of Lords on the technical point raised should succeed, it will at once convene further meetings of shareholders with a view to their passing resolutions identical with those passed on May 1, 1935.

TWO MEN WERE KILLED when a gas-holder containing 1,250,000 cu. ft. of gas exploded at Dewsbury, Yorkshire, on June 18. The top of the holder was lifted off, and people who ran from adjoining buildings saw a great sheet of flame and dense smoke. Firemen, doctors and nurses were soon on the scene. The firemen concentrated on preventing the flames from reaching another gas-holder containing 750,000 cu. ft. of gas. They were aided by a favourable wind, and their efforts were successful. The explosion damaged surrounding works and cut off the gas supply to 16,000 houses and works in the town.

THE IMPORT DUTIES ADVISORY COMMITTEE has received an application for an increase in the import duties on celluloid in sheets, rods or tubes not manufactured beyond the stage of polishing. Representations should be addressed in writing to the Secretary, Import Duties Advisory Committee, Caxton House (West Block), Tothill Street, Westminster, London, S.W.1, not later than July 16. The application for an increase in the import duty on tubes, sheets, strip, plates, discs, and circles, manufactured wholly of copper or of alloys containing more than 50 per cent. by weight of copper, has been withdrawn.

THE GOVERNMENT OF THE IRISH FREE STATE, through the Ministry of Industry and Commerce, has undertaken to issue a "new manufacture" licence under the Control of Manufactures Acts, 1932-34, to a national refining company being formed by a Dublin syndicate. The company will refine and manufacture petroleum products of all kinds. The negotiations have been brought to a successful conclusion largely through the mediation of Mr. Thomas C. J. Burgess, chairman of Parent Petroleum Interests, and chairman and joint managing director of London and Thames Haven Oil Wharves. Mr. Burgess will nominate the first board of directors and guarantee proper technical control of the erection and working of the refinery. The total capital involved is over £2,000,000.



## Inventions in the Chemical Industry

THE following information is prepared from the Official Patents Journal. Printed copies of Specifications accepted may be obtained from the Patent Office, 25 Southampton Buildings, London, W.C.2, at 1s. each. The numbers given under "Applications for Patents" are for reference in all correspondence up to the acceptance of the Complete Specification.

### Specifications Open to Public Inspection

FLUX FOR WELDING magnesium and magnesium alloys.—I. G. Farbenindustrie. Dec. 14, 1934. 26798/35.  
 WHITE-TIPPED SKINS OR FURS, process for producing.—I. G. Farbenindustrie. Dec. 15, 1934. 27876/35.  
 ARTIFICIAL LEATHER, method of producing.—Vorm A. Dynamit-A.G., Nobel and Co. Dec. 10, 1934. 27961/35.  
 HEAT TREATMENT of magnesium alloys susceptible to precipitation hardening.—I. G. Farbenindustrie. Dec. 15, 1934. 28915/35.  
 METALLIC MAGNESIUM, process of and apparatus for the continuous production.—I. G. Farbenindustrie. Dec. 14, 1934. 29177/35.  
 FERTILIZING MATERIALS contained in the wash of distilleries and for the purification of said wash, process for the extraction and recovery.—Soc. Industrielle de Nouveaux Appareils S. I. N. A. Dec. 13, 1934. 32429/35.  
 ELECTROLYTIC PRODUCTION OF ESTERS, process.—Nitroglycerin Aktiebolaget. Dec. 10, 1934. 33563/35.  
 FUSING AND ESTERIFYING COPALS.—Walpamur Co., Ltd. Dec. 10, 1934. 33657/35.  
 DIHYDROFOLLICLE HORMONE, process for the manufacture.—Schering-Kahlbaum, A.-G. Dec. 11, 1934. 34224/35.  
 OIL SOLUBLE RESINS, production.—Bakelite, Ltd. Dec. 11, 1934. 34249/35.  
 PHENOLALDEHYDE SYNTHETIC RESINS, production.—Bakelite, Ltd. Dec. 11, 1934. 34250/35.  
 WATER INSOLUBLE BASIC PRODUCTS in the presence of a substratum, manufacture.—I. G. Farbenindustrie. Dec. 14, 1934. 34379/35.  
 IODIZED BILE ACIDS.—P. Goedrich. Dec. 15, 1934. 34468/35.  
 TREATMENT OF TEXTILE MATERIALS.—I. G. Farbenindustrie. Dec. 13, 1934. 34531/35.  
 FLUID COMPOSITIONS.—Bendix Aviation Corporation. Dec. 14, 1934. 34637/35.  
 ARSENIC COMPOUNDS of the naphthoquinone series, manufacture.—Soc. of Chemical Industry in Basle. Dec. 15, 1934. 34646/35.  
 SPLINTERLESS GLASS, manufacture.—I. G. Farbenindustrie. Dec. 14, 1934. 34873/35.  
 POLYMERIZATES, manufacture of very thin sheets.—Deutsche Celluloid-Fabrik. Dec. 15, 1934. 34873/35.  
 ESTERS OF ALPHA METHACRYLIC ACID, manufacture.—Röhm and Haas, A.-G. Dec. 14, 1934. 34896/35.

### Specifications Accepted with Date of Application

ETHYL CHLORIDE, manufacture and production.—Coutts and Co., and F. Johnson (Legal representatives of J. Y. Johnson (deceased)). (I. G. Farbenindustrie). Dec. 5, 1934. 448,269.  
 DYEING WITH VAT DYESTUFFS.—I. G. Farbenindustrie. Dec. 9, 1933. 448,272.  
 TITANIUM PIGMENTS, manufacture.—A. Carpmal (I. G. Farbenindustrie). Dec. 8, 1934. 448,345.  
 QUARTERNARY AMMONIUM COMPOUNDS, manufacture and production.—Coutts and Co., and F. Johnson (Legal representatives of J. Y. Johnson (deceased)). (I. G. Farbenindustrie). Dec. 10, 1934. 448,251.  
 ALIPHATIC ACIDS, purification.—Carbide and Carbon Chemicals Corporation. June 13, 1934. 448,145.  
 OILING CALCIUM CYANAMIDE, processes.—R. I. Blackburn (Bayerische Stickstoff-Werke). Aug. 6, 1935. 448,309.  
 CATALYTIC OXIDATION OF KETOLS.—Naamlooze Vennootschap de Bataafsche Petroleum Maatschappij. Sept. 22, 1934. 448,313.  
 MONOALKYLOLAMINES, production.—Naamlooze Vennootschap de Bataafsche Petroleum Maatschappij. Oct. 1, 1934. 448,373.  
 SYNTHETIC RESINS, manufacture.—Soc. of Chemical Industry in Basle. Oct. 5, 1934. 448,215.  
 POLYNUCLEAR CYCLIC ALCOHOLS, manufacture.—W. W. Groves Nov. 16, 1934. (Addition to 31,739, 34.) 448,225.  
 NON-KNOCKING MOTOR FUELS, manufacture and production.—Coutts and Co., and F. Johnson (Legal representatives of J. Y. Johnson (deceased)). (I. G. Farbenindustrie). Oct. 8, 1934. 448,690.  
 FRACTIONAL DISTILLATION and like operations, method and means.—A. J. V. Underwood. Nov. 10, 1934. 448,556.  
 3-AMINO-QUINOLINES, manufacture.—I. G. Farbenindustrie. Dec. 15, 1933. 448,502.  
 3-AMINOQUINOLINE DERIVATIVES, manufacture.—I. G. Farbenindustrie, and W. W. Groves. Nov. 30, 1934. 448,504.  
 AZO DYESTUFFS, manufacture.—W. W. Groves (I. G. Farbenindustrie). Dec. 3, 1934. 448,505.  
 COLOUR LAKES, process for the manufacture.—A. Carpmal (I. G. Farbenindustrie). Dec. 5, 1934. 448,508.  
 FILAMENTS AND FILMS, process for the manufacture.—I. G. Farbenindustrie. Dec. 6, 1933. 448,447.

LOWER ALIPHATIC ANHYDRIDES, manufacture.—H. Dreyfus. Dec. 7, 1934. 448,452.  
 CONVERSION OF OLEFINS into sulphuric esters.—E. I. du Pont de Nemours and Co. Dec. 7, 1933. 448,457.  
 WATER-INSOLUBLE AZO DYESTUFFS and intermediate products therefor, process for the manufacture. I. G. Farbenindustrie. Dec. 8, 1933. 448,459.  
 CYCLIC ESTERS, manufacture.—E. I. du Pont de Nemours and Co. Dec. 12, 1933. 448,708.  
 WATER-SOLUBLE SALTS OF AMIDETHERS, imidothioethers, or amidines, manufacture.—I. G. Farbenindustrie. Dec. 15, 1933. (Samples furnished). 448,469.  
 AQUEOUS LIQUIDS FROM PHENOLS and contingently other accompanying substances.—Coutts and Co., and F. Johnson (Legal representatives of J. Y. Johnson (deceased)). (I. G. Farbenindustrie). Dec. 27, 1934. 448,712.  
 METALLIC MAGNESIUM from magnesium oxide, process for the manufacture.—Osterreichisch Amerikanische Magnesit, A.-G. May 4, 1934. 448,536.  
 FORMALDEHYDE AND OTHER OXIDATION PRODUCTS from hydrocarbons of the paraffin series having more than one carbon atom in the molecule, process for making.—Gutehoffnungshutte Oberhausen, A.-G. April 7, 1934. 448,733.  
 INDIGOID DYESTUFFS, manufacture.—Soc. of Chemical Industry in Basle. April 21, 1934. 448,654.  
 GLASS TUBE CONNECTION, more particularly for laboratory and chemical technical apparatus.—Vereinigte Lausitzer Glaswerke, A.-G. April 30, 1935. 448,658.  
 HALOGENATED ALCOHOLS and halogenated ethers, production.—Naamlooze Vennootschap de Bataafsche Petroleum Maatschappij. June 23, 1934. 448,659.  
 AZO DYESTUFFS, process for the manufacture.—Chemical Works, formerly Sandoz. July 28, 1934. 448,592.  
 MONOAZO DYESTUFFS, manufacture.—W. W. Groves (J. R. Geigy, A.-G.). Oct. 4, 1935. 448,601.  
 NON-POISONOUS TOWN GAS, manufacture.—Non-Poisonous Gas Holding Co., Ltd. Sept. 26, 1935. 448,751.  
 POTASSIUM SOAPS, process for improving.—J. A. Chemische Fabrik Benckiser, Ges., and F. Draischach. Oct. 31, 1935. 448,608.

### Amended Specifications Published

ARTIFICIAL PRODUCTS, manufacture from cellulose esters.—Boehringer and Soehne Ges. 413,368.

### Applications for Patents

MELAMINE, manufacture.—A. Carpmal (I. G. Farbenindustrie). 16016.  
 POLYVINYL ALCOHOLS, treatment.—Chemische Forschungsges. (Germany, June 5, '35.) 1560, 15751.  
 AVIATION SPIRIT, manufacture.—Coal and Allied Industries, Ltd., T. Cohn, and F. Levy. 15996.  
 POLYMERIZATION OF ORGANIC COMPOUNDS.—H. R. Dittmar (E. I. du Pont de Nemours and Co.). 16165.  
 SYNTHESIS OF HYDROCARBONS under ultra-pressure.—E. Fischer. (Czechoslovakia, Feb. 15.) 16168.  
 AMYLACEOUS DISPERSION OF GELS, production.—F. G. Francis. 15915.  
 DYESTUFFS, manufacture.—N. V. Gevaert Photo Production (Austria, June 6, '35.) 15969.  
 LEAD, ETC., manufacture.—Goodlass Wall and Lead Industries, Ltd., B. Jones and C. Wilson. 15641, 15642.  
 LOWER ALIPHATIC PRIMARY AMINO ALCOHOLS, production.—S. J. Grose (Girdlar Corporation). 15823.  
 AZO DYESTUFFS, manufacture.—W. W. Groves (I. G. Farbenindustrie). 15647.  
 ISOCYCLIC COMPOUNDS, manufacture.—W. W. Groves (I. G. Farbenindustrie). 15750.  
 COLOURED COLLOIDS, manufacture.—W. W. Groves (I. G. Farbenindustrie). 15965.  
 VAT DYESTUFFS, manufacture.—I. G. Farbenindustrie. (Germany, June 7, '35.) 15849.  
 THIAZOLIDINE DERIVATIVES, manufacture.—I. G. Farbenindustrie. (Germany, June 7, '35.) 15970. (Germany, Jan. 10, '35.) 15971.  
 SULPHONIUM COMPOUNDS, manufacture.—I. G. Farbenindustrie. (Austria, June 6, '35.) 16017.  
 PROCESS OF IMPROVING RESISTANCE to corroding agents of aluminium base alloys.—I. G. Farbenindustrie. 16025.  
 PHTHALOCYANINES, manufacture.—Imperial Chemical Industries, Ltd., A. Riley. 15684, 15685.  
 POLYMERIZATION PRODUCTS, manufacture.—Imperial Chemical Industries, Ltd., L. B. Morgan, B. J. Habgood and R. Hill. 15686.  
 PLASTIC COMPOSITIONS.—Imperial Chemical Industries, Ltd. 15687.

- AZO DYESTUFFS, manufacture.—Imperial Chemical Industries, T. C. Alcock. 15688.
- AUTOMATIC TEMPERATURE CONTROL.—Imperial Chemical Industries, Ltd., J. Mendoza and G. S. J. White. 15844.
- HYDROGENATING, ETC. CARBONACEOUS LIQUIDS.—T. D. Kelly. 15906.
- MIXTURES OF CARBONACEOUS MATERIAL and oil, distillation.—C. H. Lander, W. B. Mitford. 15683.
- ESTERS, electrolytic production.—V. Ohman. 15936.
- ACTIVATED CARBON, production.—S. Percival. 15912.
- ARTIFICIAL DYESTUFFS.—E. I. Strasser. (Germany, March 11.) 15679.
- CHEMICAL REACTIONS involving the presence of finely divided solid materials.—Techno-Chemical Laboratories, Ltd., N. Testrup. 16095.
- CONTROLLING TEMPERATURE, apparatus.—W. W. Triggs (E. I. du Pont de Nemours and Co.). 15725.
- RED LEAD, manufacture.—A. Wreschner. 15657.
- PALLADIUM, process for treating.—American Platinum Works, J. S. Streicher. 16309.
- MOULDING COMPOSITIONS FROM PYENOLALDEHYDE SYNTHETIC RESINS, manufacture.—Bakelite, Ltd. (Bakelite Ges.). 16771.
- RESINOUS PRODUCTS, manufacture.—Beck, Koller, and Co. (England), Ltd. (United States, March 5.) 16897.
- UREA-FORMALDEHYDE CONDENSATION PRODUCTS, manufacture.—British Xylonite Co., Ltd., J. H. Hetherington. 16562.
- THIAZATHIONUM CHLORIDES, preparation.—Calco Chemical Co., Inc. (United States, June 20, '35.) 16351.
- ANTIRACHITIC VITAMIN FROM NATURAL PRODUCTS, process for isolating.—A. Carpmæl (I. G. Farbenindustrie). 16360.
- IODIFEROUS HYDNOCARPUS FATS, preparation.—A. Carpmæl (I. G. Farbenindustrie). 16361.
- CONDENSATION PRODUCTS, manufacture.—A. Carpmæl (I. G. Farbenindustrie). 16362.
- CONDENSATION PRODUCTS OF THE ANTHRAQUINONE SERIES, manufacture.—A. Carpmæl (I. G. Farbenindustrie). 16484.
- RECOVERY OF BERYLLIUM COMPOUNDS, process.—Deutsche Gold- und Silber-Scheideanstalt vorm. Roessler. (Germany, June 20, 1935.) 16367.
- HARDENING PROTEIN MATERIALS, means for.—E. I. du Pont de Nemours and Co. 16356.
- VULCANISATION OF RUBBER.—E. I. Du Pont de Nemours and Co. 16508.
- ORGANIC ACID AMIDES, manufacture.—E. I. du Pont de Nemours and Co. (United States, July 20, '35.) 16916.
- FLUID PROCESSING APPARATUS.—Enamelled Metal Products Corporation (1933), Ltd. (Pfandler Co.). 16708.
- DYESTUFF INTERMEDIATES.—A. E. Everest, J. A. Wallwork, and J. W. Leitch & Co., Ltd. 16775.
- CONDENSATION PRODUCTS, manufacture.—Imperial Chemical Industries, Ltd., and R. F. Goldstein. 16764.
- COMPOSITIONS containing chlorinated compounds.—Imperial Chemical Industries, Ltd. 16915.
- AZO DYESTUFFS, production.—G. W. Johnson (I. G. Farbenindustrie). 16641.
- COMPOUNDS of anthraquinone series containing nitrogen and sulphur.—G. W. Johnson (I. G. Farbenindustrie). 16745.
- POLYMERISATION PRODUCTS, production.—G. W. Johnson (I. G. Farbenindustrie). 16746.
- SATURATED HYDROCARBONS, production.—H. E. Potts (International Hydrogenation Patents Co., Ltd.). 16705.
- CARBONACEOUS MATERIALS, treatment.—H. E. Potts (International Hydrogenation Patents Co., Ltd.). 16706.
- LAEVO-ASCORBIC ACID, process for manufacture.—T. Reichstein. (Switzerland, June 18, '35.) 16843, 16844.
- CHLOROPHYLL, ETC., production.—B. A. Rewald. 16795.
- HYDROGEN PEROXIDE, production.—H. Schmidt. (Germany, June 22, '35.) 16439.
- DISTILLATION ETC., OF MUSTS, containing acetone ethyl alcohol and butyl alcohol.—Soc. des Etablissements Barbet. (France, June 13, '35.) 16688.
- ALKYL- AND ACYL-DERIVATIVES OF PHENOLS, manufacture.—W. P. Williams (Schering-Kahlbaum). 16485.

## Chemical and Allied Stocks and Shares

LARGELY owing to the commencement of a new Stock Exchange account, industrial and other sections of the stock and share markets have been more active this week. Shares of chemical and associated companies were again very steady. Imperial Chemicals were bought on any reaction, there being hopes in the market that a satisfactory advance in price may be shown when effect is given to the scheme for consolidating the capital. United Molasses were in larger demand, but also show little change in price at the time of writing, the disposition being to await next month's annual meeting of the Distillers Co. for any reference that may be made to the progress and more immediate outlook for industrial alcohol. Distillers have risen over 2s. on the hopes which continue to attach to the forthcoming results, but partly owing to the recent dividend announcement of the company which distributes the petrol alcohol blend of motor spirit in which Distillers is interested. Greff Chemicals Holdings 5s. ordinary shares were little changed at 8s. 9d., as were the 10s. preference shares at 10s. 7½d. Unilever were firmer and have continued to hold their gain of a short time back, it being contended in the market that the company is likely to benefit from the upward tendency in prices of West African produce, in view of the widespread interests of the Unilever group in West African produce companies. Continued market talk of a possible bonus from Triplex Glass later in the year maintained a good deal of interest in the shares of this company. International Nickel were higher, due partly to the better tendency of New York markets, although attention drawn to the increasing uses of nickel and nickel alloys may also have been a factor, as may have been the expectations that the price of copper may improve favourably during the next six months. The company is also a considerable producer of the latter metal. International Combustion shares were more active, the recently-announced interim dividend having tended to increase market hopes that the total dividend may be raised from 20 per cent. to 25 per cent. For the previous year about 50 per cent. could have been paid if profits had been fully distributed. Cannon Iron Foundries shares received more attention. This company also announced an interim dividend recently and there are anticipations of an increase in the rate of dividend for the year. Dorman Long ordinary and preferred ordinary shares have not kept best prices, due to a wider realisation that recent dividend estimates in the market may be on the optimistic side, bearing in mind the indications already given by the directors that they intend to deal conservatively with profits. Imperial Smelting were rather dull, although hopes of the resumption of dividends with a modest payment for the current year still persist. Burt, Boulton and Haywood again show no change. The shares are held rather firmly, particularly in view of the possibility of a larger total dividend which have been emphasised since the raising of the interim payment earlier

in the year. British Glues were again steady, awaiting the past year's results. Associated Portland Cement made higher prices and Courtaulds were active. Pinchin Johnson received most attention among paint shares. Goodlass Wall were steady. On the basis of last year's 6 per cent. dividend the yield offered by the latter shares is not large, but this has to be read in relation to the belief that over the next few years considerably higher profits may be in prospect. Cellulose acetate were better on their maiden dividend of 2½ per cent. Fison, Packard and Prentice and Cooper, McDougall and Robertson were steady and are unchanged at the time of writing. Conselt Iron shares were again active, partly on the view that if expectations of a further increase in pig-iron and North East haematite prices are realised it will enhance prospects of a resumption of dividends for the current year with a favourable payment. The ordinary capital is now in the form of stock which is quoted in 6s. 8d. units effect having been given to the capital reorganisation scheme. Oil shares were more prominent, largely owing to the favourable impression created by the statements at the "Shell" meeting.

## Books Received

- Fundamental Physical Properties of Lac. Part III.—Electrical Properties.** By L. C. Verman. Technical Paper No. 7. London: Shellac Research Bureau, India House, Aldwych, London.
- Rates of Adsorption of Moisture by Shellac Films.** By Wm. Howlett Gardner and William Kappenberg. Technical Paper No. 15. Shellac Research Bureau of the Polytechnic Institute of Brooklyn. Reprinted from Industrial and Engineering Chemistry, Vol. 28, No. 4, April, 1936.
- Road Notes Great Britain, 1935-6.** London: British Road Federation, Ltd. Pp. 25. 6d.
- Colorimetric Methods of Analysis.** By F. D. Snell and C. T. Snell. London: Chapman and Hall, Ltd. Pp. 766. 45s.
- Triethanolamin und andere Aethanolamine.** By Emil J. Fischer. Berlin: Allgemeiner Industrie-Verlag G.m.b.H. Pp. 84. RM. 5.60.

## Official Publications

- Report of Test by the Director of Fuel Research on a Retort of the Coal Research Syndicate, Ltd., at Mansfield Colliery, Mansfield, Nottinghamshire.** London: H.M. Stationery Office. Pp. 28. 9d.

## Chemical Trade Inquiries

The following trade inquiries are abstracted from the "Board of Trade Journal." Names and addresses may be obtained from the Department of Overseas Trade (Development and Intelligence), 35 Old Queen Street, London, S.W.1 (quote reference number).

**British West Indies.**—A firm of commission merchants established at Bridgetown, Barbados, wish to obtain the representation, on a commission or purchasing basis for Barbados and the Leeward and Windward Islands of United Kingdom manufacturers of fertilisers. (Ref. No. 530.)

**British West Indies and British Guiana.**—A firm of manufacturers' agents established at Trinidad wish to obtain the representation, on a commission basis, for Trinidad and British Guiana of United Kingdom manufacturers of drugs, medicines and proprietaries. (Ref. No. 533.)

**British West Indies and British Guiana.**—A firm of manufacturers' agents established at Trinidad wish to obtain the representation, on a commission basis, for Trinidad and British Guiana of United Kingdom manufacturers of paints and varnishes. (Ref. No. 534.)

**Canada.**—A firm of chemical manufacturers established at Montreal is desirous of representing United Kingdom manufacturers of dyestuffs, chemicals and materials for the textile, paper and canning industries for the whole of Canada on a basis to be arranged. (Ref. 543.)

## Prices of Chemical Products

WITH the exception of the products mentioned below the prices of British chemical products remain the same as reported in THE CHEMICAL AGE of June 13 (pages 546-547). Unless otherwise stated the prices given cover fair quantities net and naked at sellers' works.

**MANCHESTER.**—Generally steady price conditions have obtained on the Manchester chemical market during the past week and only in odd instances is there any indication of values showing any quotable ease. There has been no sign as yet of a seasonal falling away in the demand for chemicals against contract commitments, although a movement in this direction may be looked for within the next few weeks as the industrial holidays, particularly in the Lancashire and Yorkshire textile areas, get under way. For the time being, users are specifying for fair quantities of the principal heavy chemical products, although new business this week has been of no more than moderate dimensions. Among the by-products, the tolouls and xylols have been on offer at slightly lower prices, but there has been no alteration in the position of carbolic acid and most other materials.

**SCOTLAND.**—There has been a steady day to day demand for chemicals for home trade during the week, and a little improvement in the demand for export. Prices generally continue firm at about previous figures, with no important changes to report.

**ACID, OXALIC.**—LONDON: £47 17s. 6d. to £57 10s. per ton, according to packages and position. SCOTLAND: 98/100%, £48 to £50 ex store. MANCHESTER: £49 to £55 ex store.

**ACID, TARTARIC.**—1s. per lb. less 5%, carriage paid for lots of 5 cwt. and upwards. LONDON: 11½d. less 5%. SCOTLAND: 1s. 0½d. less 5%. MANCHESTER: 11½d. to 1s. per lb.

**CADMIUM SULPHIDE.**—4s. to 4s. 3d. per lb.

**CARBON BLACK.**—3 11/16d. to 4 13/16d. per lb. LONDON: 4½d. to 5d.

**LAMPBLACK.**—£28 to £30 per ton.

**POTASH, CAUSTIC.**—LONDON: £42 per ton. MANCHESTER: £38.

MANCHESTER: Brown, £9 10s.; grey, £11.

**POTASSIUM CHLORATE.**—LONDON: £37 to £40 per ton. SCOTLAND: 99½/100%, powder, £37. MANCHESTER: £38.

**ACID, CARBOLIC.**—Crystals, 6½d. to 7½d. per lb.; crude, 60's, 2s. 3d. to 2s. 6d. per gal. MANCHESTER: Crystals, 7d. per lb.; crude, 2s. 4d. per gal. SCOTLAND: 60's, 2s. 6d. to 2s. 7d.

**CREOSOTE.**—B.S.I. Specification standard, 5½d. per gal. f.o.r. Home, 3½d. d/d. LONDON: 4½d. f.o.r. North; 5d. London. MANCHESTER: 4½d. to 5s. SCOTLAND: Specification oils, 4d.; washed oil, 4½d. to 4¾d.; light, 4½d.; heavy, 4½d. to 4¾d.

**ACETATE OF LIME.**—Brown, £8 to £8 10s. per ton; grey, £10 5s. to £10 15s. Liquor, brown, 30° Td., 8d. per gal. MANCHESTER: Brown, £9 10s.; grey, £11.

## New Companies Registered

**Craig and Milns (Rochdale), Ltd.**—Registered June 20. Nominal capital, £5,000. Oil merchants, refiners and mixers, grease manufacturers, tallow refiners, manufacturers of and dealers in oil and water paints, colours, varnishes, polishes, lacquers, cellulose products and solvents, bituminous paints, etc. Directors: Albert Craig, "Dalkeith," Wardle Road, Wardle, near Rochdale; Felix J. Milns, John A. Milns.

**Gas Defence, Ltd.,** Standbrook House, 2/5 Old Bond Street, London, W.1.—Registered June 18. Nominal capital, £10,000. Manufacturers, suppliers and purveyors of and dealers in all kinds of appliances for protection against gas attack or poison-gas, and particularly air filters and gas masks useable in relation to anti-gas protection or poison-gas shelters, etc. Directors: Stanley L. Groom, Robert Schneider, Oscar Roditi. Remuneration £50.

## Company News

**Ipswich Beet Sugar Factory, Ltd.**—A dividend of 8 per cent., tax free, is announced.

**Ely Beet Sugar Factory, Ltd.**—The dividend is maintained at 15 per cent., tax free.

**American Cyanamid Co.**—A quarterly dividend of 15 cents per share on Class "A" and "B" shares is payable July 1.

**The King's Lynn Beet Sugar Factory, Ltd.**—Dividend payment is reduced from 8 per cent., tax free, to 6 per cent., tax free.

**Metal Industries.**—The first interim dividend for the year ended March 31 last of 2½ per cent., less tax, is announced on ordinary and "B" ordinary stock, payable on July 1.

**The English Beet Sugar Corporation, Ltd.**—A final dividend of 5 per cent. is being paid, making 20 per cent., tax free, for the year ended March 31, 1936, the same as in 1934-35.

**I. G. Chemie of Basle.**—The net profits for 1936 of I. G. Chemie, of Basle, the Swiss holding company of the German Dye Trust, amounted to 8,700,000 Swiss francs (against 8,580,000 S.f.). A dividend of 7 per cent. is announced.

**Continental Tintex and Dye Products.**—The profit for the year to March 31, 1936, was £114, compared with a net loss of £64, plus legal costs of reconstruction, £98, in the previous year. The debit balance is now reduced to £47.

**Cellulose Acetate Silk Co., Ltd.**—The directors recommend a dividend of 2½ per cent., less tax, on the ordinary share capital for the year ended March 28, 1936, payable on August 29, 1936. This is the first dividend to be paid by the company, which was registered in 1928.

**British Bitumen Emulsions.**—The trading profit for 1935 amounted to £5,965, against £3,817, and income from investments £203, and profit on sales of investments £336. Fees absorbed £244 and depreciation £3,417, leaving net profit £2,843, compared with a net loss in the previous year of £1,656, which reduces debit balance to £337.

**W. and T. Avery, Ltd.**—The directors recommend a final dividend on the ordinary shares of 10 per cent., less tax, for the half-year ended March 31, 1936, making a total distribution of 15 per cent., less tax, for the year. The dividend is thus maintained on the larger capital resulting from the 20 per cent. capital bonus distributed last year.

**Australian Commonwealth Carbide.**—The report for the year ended January 31, 1936, shows net profit £12,968, against £15,515, to which is added directors' fees recovered £345, and balance brought forward £685, making available £13,998. The directors recommend a dividend of 6 per cent., less tax, on the preferred ordinary shares (5 per cent.) absorbing £7,776, writing off preliminary expenses £4,000 (£10,000), carrying forward £2,222.

**Stanton Ironworks Co., Ltd.**—The accounts to March 31, 1936, show net profits, after providing for taxation and £50,000 for contingencies, amounted to £377,266, as against £300,758 for the previous year, when a similar provision of £50,000 for contingencies was made. The directors recommend that £50,000 be provided for additional depreciation, a similar sum being provided in the previous year. The ordinary dividend is maintained at 10 per cent., a final of 6 per cent., less tax, now being recommended.

**British Plaster Board, Ltd.**—In a preliminary statement the profit for the year to April 30, 1936, is given as £413,087. This is £274,087 more than in 1934-35, when £139,000 was earned. The directors recommend a final dividend of 30 per cent., less tax, on the ordinary shares. This brings the year's payment to 50 per cent. It will be payable on July 14 on a capital of £696,810. The total dividend for the previous year was 40 per cent., and was paid on a capital of £374,400. It is proposed to increase the transfer to reserve from £25,000 to £45,000, after which £4,749 will remain to go forward, compared with £4,614 brought in.

**Edgar Allen and Co., Ltd.**—The directors, in their report for the year to March 31 last, recommend a dividend on the ordinary shares of 5 per cent., less tax, the first payment on these shares since that of 2½ per cent. in respect of 1920-30. The past year's profits, after charging £15,847 for depreciation and £10,400 for income-tax, amount to £32,182, against £38,283 in 1934-35, when income-tax absorbed £2,566 and depreciation £17,982. The preference dividend for the past year requires £11,625 and the proposed ordinary dividend £10,953. Reserve receives £12,500—the first allocation to this fund for many years. The carry-forward is £23,762, against £26,658 brought in.







# Metallurgical Section

January 4, 1936

## Inclusions in Iron and Steel

THE problem of the non-metallic inclusions in metallurgical products is one that has always engaged the attention of metallurgists, especially during the last few years. Hitherto it was thought that these inclusions might be connected in some way with the quality of the metal. That is why, for more than one hundred years, investigators have worked on the problem in the endeavour to ascertain these relations and to accurately determine the constituents of non-metallic inclusions, especially sulphur and oxygen. There is, however, another equally important factor connected with non-metallic inclusions, to which less attention has been given, *i.e.*, the history of the metal. The inclusions visible in a sample of metal are very often the manifestation of one or more phases of the process of manufacture, which suggests that they may be regarded as internal slags, and in certain cases, an examination of the inclusions in a metal, coupled with a knowledge of the complete chemical analysis and a microscopic examination of the elements of its structure, may enable the investigator to partially retrace its previous history.

Whilst making no claim to break new ground or to exhaust such a vast subject, Professor A. M. Portevin and M. Rene Castro have recently endeavoured to place on record (Iron and Steel Institute, September, 1935) details of a large number of characteristic types of inclusions found in iron and plain carbon steels, classified according to their probable nature and their probable mode of origin. The appearance of these inclusions, they emphasised, is an extremely useful factor to consider in connection with their determination, but is by no means entirely specific. Although it may be a quick and to a certain extent instantaneous means of enabling a skilled observer to identify the nature of the constituents in certain specific cases, it should be noted that this method of identification depends not only on the nature of the inclusions, but on many other factors, such as the temperature of formation, properties of the inclusion (viscosity and surface tension), degree of mixing, state of the metal (liquid in process, or at the end of solidification), and origin (precipitation within the metal, or from an existing inclusion by reduction of the latter). For instance, the high manganous sulphide inclusions in the metal as cast, may be of crystalline appearance (polyhedral or dendritic) or globular, depending upon whether they form in the liquid metal (carburised cast irons or steels) or during the process of solidification (mild steels).

Generally speaking, a crystalline appearance corresponds to a crystalline formation in a liquid metal, and a globular appearance to a liquid or vitreous state of the inclusion at the moment of formation, but this must not be taken as an absolute rule. In the micrographic identification of the inclusions, the physical processes

(colour, sheen and transparency by different modes of illumination) also play just as important a part as the chemical processes (etching by reagents). By attentively studying the inclusions in the metal, the skilled observer is able to reconstruct certain "stages" or retrace certain operations performed during the manufacture of the metal, and which elude all other methods of investigation. These operations leave indelible traces on the nature or appearance of the inclusions. Nevertheless, the greatest prudence must be exercised in pronouncing judgment on these inclusions, as a very large number of different inclusions are met with in steel and it may be difficult to arrive at a true assessment.

This investigation which was carried out in Paris will ultimately be completed by work dealing with the morphology of the inclusions in the iron alloys containing special elements, chromium in particular. It also demonstrates the irregular nature of the action of the additions, which cause localised increases of concentration and also of temperature, the latter being revealed by the melting of certain refractory inclusions. Inclusions, however, are much more difficult to identify in forged metal, where they lose their typical appearance.

## Steel Industry Expansions

IN his address to the shareholders of the South Durham Steel and Iron Co., Ltd., at Middlesbrough, on December 18, Lord Furness referred to the proposal to assist the distressed areas by the building of a new steelworks on the North-East Coast. He pointed out that there is a large amount of modern plant still idle in some of the works on the North-East Coast, and careful investigation appears to be necessary to see whether this idle plant cannot be put into operation before a decision is arrived at to increase further the steelworks capacity of the area concerned. Lord Furness was evidently referring to the persistent efforts which are being made to secure a resumption of steel manufacture at Jarrow-upon-Tyne. This matter has been before the steel industry for several months, and discussions are still proceeding with regard to the proposal to build new steel works on a site which is now vacant. The Government, moreover, are anxious to achieve concrete schemes of industrial development for the Special Areas, and the establishment of a new steelworks offers a means of solid assistance for a seriously hit district. The Government, however, have also imposed upon the steel industry the task of reorganising on national lines, and it is very questionable whether the progress already made by the industry would not be jeopardised by the laying down of a new unit of production at Jarrow. It seems probable that if any decision is taken to put down a new steelworks, to operate the basic Bessemer process, as Lord Furness



hinted, the undertaking will be a joint one in which existing steel firms in the area will co-operate, rather than that an entirely new concern be formed for the purpose.

### Death of Mr. P. C. Gilchrist

THE recent death of Mr. Percy Carlyle Gilchrist in his 84th year, after a long illness, calls to mind an important development in the steel-making industry. Following the introduction of Bessemer's process for the "preparation of steel without fuel" (1856) it was ultimately found that this acid Bessemer process had two disadvantages. In the first place phosphorus and sulphur could not be removed owing to the reduction of their oxides by iron and therefore only special "Bessemer pigs," free from phosphorus and very low in sulphur, could be used. Secondly, many of the resulting ingots contained blow-holes. In 1876, however, the first of these problems was solved, for Gilchrist, working with Mr. Sidney Thomas, found that by lining the converter with burnt dolomite or magnesite, instead of ganister, and by adding a quantity of lime to the charge, the whole of the phosphorus and some of the sulphur could be removed. This discovery of the Thomas-Gilchrist or basic process, for making steel from phosphoric pig iron in such a way as to absorb the phosphorus, was the result of the direct application of a scientific principle in research methods, *i.e.*, that of using a basic lining and adding lime, a basic material, in order to retain the acidic substances which were produced by the oxidation of phosphorus and sulphur. Mr. Gilchrist received his metallurgical training at the Royal School of Mines, where he was Murchison Medallist. He was elected a Fellow of the Royal Society in 1891 and was also a Chevalier of the Legion of Honour and a vice-president of the Iron and Steel Institute.

### Birmingham University Presentation

THE 20th annual dinner of the University of Birmingham Metallurgical Society was held at Edgbaston just before Christmas, when a presentation was made to Mr. H. Harris, who has recently relinquished the post of senior lecturer in metallurgy at the University. In making the presentation, Professor D. Hanson, president of the Society, said that Mr. Harris was terminating a very long connection with the metallurgical department of the University and was an old student of Mason College. He was, moreover, a metallurgist of some note, who had smelted metals in nearly all parts of the world, and as an explosive expert he had carried out the spectacular task of blowing up the wreck of a steamer which had sunk in the Suez Canal with 100 tons of explosives on board.

### Non-Adhesive Nickel Deposits

IN the majority of electro-deposition processes, such as general electro-plating, and the building up of new and worn parts, it is necessary to secure a high degree of adhesion between the coating and the base, and considerable research has been carried out on the processes involved and on methods of testing adhesion. For certain purposes, however, *i.e.*, electro-forming and electro-typing, the deposited metal requires to be stripped from the base or mould, and the success of the operation depends on ready separation of the two. In this connection a recent paper by Mr. E. A. Ollard

("Metal Industry," November 22, 1935, page 519) gives a critical summary of processes involved in the production of the separable type of deposit. In electro-forming on non-metallic moulds such as gutta-percha, wax or plaster, special preparation to ensure non-adhesion is unnecessary. In the case of deposition on metal moulds, however, ease of separation may be secured by the use of a metal base to which the deposit does not adhere, *e.g.*, aluminium, on which the natural oxide layers formed on the surface inhibit adhesion; the protection of the metal base by a mechanically applied layer of wax or other similar material; the formation on the basis metal of oxide or sulphide films by interaction with suitable reagents; the formation on the basis metal, by chemical or electro-chemical means, of thin layers of such a metal as aluminium; or treatment of the base with colloids to produce adsorbed colloid layers. These methods are individually discussed by Mr. Ollard, who gives special attention to the formation of oxide or sulphide films.

### Magnesium Production in Russia

THE organisation of a magnesium industry in Russia was first decided upon in 1929, and a research programme was immediately formulated for the various institutes under State control. Experimental works were erected in 1931 and are still operating. The principal questions which have received attention include the dehydration of artificial carnallite (as obtained by the treatment of certain natural deposits), the design of electrolytic cells, methods of refining the metal by remelting under fluxes and by distillation in vacuo, and also a method for the regeneration of hydrochloric acid using chlorine, steam and coke. Interesting results have been obtained by reducing magnesite with silico-aluminium, and in spite of the high temperature (1,400° C.) and low vacuum demands (a few tenths of a millimetre of mercury) some effective furnaces for vacuum operation have been designed. It is hoped ultimately to produce magnesium at the same cost as aluminium.

### Etching Technique for Stainless Steels

CERTAIN metals are difficult to etch satisfactorily, when required for study under the metallurgical microscope. This is particularly true of stainless steels, because they resist attack by the ordinary reagents. Generally, it has been necessary to use strong mixed acids to reveal the structures, thus necessitating great care in handling and disposal after use. A new method used at the U.S. Bureau of Standards in a study of the changes induced in stainless steels upon welding promises to be far superior to all others. This method consists in etching electrolytically in 10 per cent. oxalic acid, the specimen being the anode and a piece of platinum acting as the cathode; current is supplied from a 6-volt storage battery. Carbides are revealed when the etching has proceeded for 15-30 seconds; an additional 30-45 seconds will reveal also the grain boundaries in steels of the 18 per cent. chromium 8 per cent. nickel type. The solution is stated to be relatively rapid in etching action and does not stain the specimen, a drawback of nearly all other methods. By further study it is possible that a similar etching technique will be found useful in the study of other alloys where existing methods are not as perfect as they might be.

## New Ways of Producing Magnesium Metal

### The Development of an Austrian Process

**T**HE current method of producing magnesium electrolytically from anhydrous magnesium chloride in a bath containing molten fluxing material is accompanied by a number of difficulties. One of these is the fact that, to produce a high grade magnesium product, raw materials of high purity and perfectly anhydrous must be employed. Another difficulty is that magnesium, in consequence of its low specific gravity, rises to the surface of the electrolytic bath as it is reduced, which means that special precautions must be taken to prevent its oxidation; in addition the chlorine gas produced at the anode must be carefully excluded from the reduced magnesium to prevent it from recombining with the metal. Special care must also be taken to lead away this chlorine gas from the electrolytic bath and to avoid any leakage of the same into the works. The high consumption of electric energy makes the cost of production of the magnesium high, notwithstanding the practically inexhaustibility and cheapness of magnesium minerals and salts which can be utilised for producing the metal. Added to these difficulties, impurities in the fluxing materials (particularly alkalies) may make a special refining of the electrolytically produced magnesium essential.

#### A Furnace Reduction Process

It is, therefore, not surprising that many attempts have been made to develop a furnace reduction process and that numerous patents relating to these attempts are to be found in the patent literature of England and other countries. Nevertheless, the furnace production of magnesium hitherto has not been developed into a practical commercial process.

When carbon is used to reduce magnesium oxide, even by the exclusion of air, the production proceeds according to the equation  $MgO + C = Mg + CO$ . At temperatures below about  $2,000^{\circ}C$ . this reaction is a reversible one, resulting in the magnesium becoming reoxidised and free carbon being produced in the form of soot. At a temperature of  $2,000^{\circ}C$ . and upwards magnesium, with a boiling point of  $1,120^{\circ}C$ ., is produced in vapour form in the furnace and passes out of it mixed with the furnace gases; direct reduction of magnesium oxide to obtain a solid or liquid metal is impossible by thermal reduction with carbon. In the condensation of the magnesium vapour, a reversal of the above named reaction causes a large part of the reduced magnesium to revert to oxide, while the particles not completely oxidised receive a skin of oxide which prevents them from cohering. Attempts to overcome this difficulty include the employment of reduction materials like aluminium, silicon, and ferro-silicon, which do not form volatile oxides, but obviously the use of such materials make the reduction a costly operation.

#### A Non-Oxidising Atmosphere

Reference to these difficulties are contained in an article by Dr. Willy Machu, of Vienna, entitled "New Ways of Producing Magnesium," which is published in "Metall u. Erz," No. 23, 1935, where he also describes a method of overcoming the difficulties of furnace production of magnesium, developed and patented by the Österreichische Americanische Magnesit A.-G. This method, as now improved, together with the apparatus for carrying it out, is the subject of Austrian Patents 130,209, 133,126, 133,874, 134,610, 138,010, and 140,560.

The original patent described the reduction of magnesium oxide by carbon in an electric furnace with air exclusion, in which hydrogen was introduced in sufficient quantity to suppress the re-oxidising of the magnesium by carbon monoxide; this involved the employment of an excess of hydrogen of 5-10 times the carbon monoxide present. The heating up

of this large volume of hydrogen to the furnace temperature of  $2,000^{\circ}C$ . or more was a serious disadvantage, but it was discovered that the addition of the hydrogen was just as effective when made after instead of before the reduction, and was also a way of rapidly cooling the magnesium vapour below the melting temperature. It was claimed that this way of operating increased the output of magnesium and also much improved the economic aspect of the process. The process as later improved also employs an electric furnace and devices for freeing the magnesium vapour from dust carried over with it. The cooling of the magnesium vapour is also assisted by water-jacketing the tube conductors, as well as by the addition of hydrogen.

An important feature of this process is that it is continuous; the magnesium metal is distilled from the furnace, and when cooled to the liquefying point, yields a metal of high purity. Formerly, a filtering medium was employed to remove the dust carried over with the gas-vapour, this consisted of burnt sintered magnesite or coke breeze contained in two tubes arranged one over the other through which the gas-vapour was made to pass. By a valve system the filtering medium could be moved and new active filtering surfaces presented to the gas-vapour. The clogging of this material with dust and thereby increasing the resistance to the passage of the gas-vapour, led to the introduction of settling chambers for the dust removal, these being operated on the well-known principle of frequently changing the direction of the gas-vapour stream and also slowing down its velocity. The chamber, of course, must be maintained at a temperature above the liquefying point of the magnesium vapour. This alteration in practice is referred to in Austrian Patent 138,410.

#### Condensation of the Metal

After dust removal the magnesium vapour is conducted through a heated zone, in which a somewhat high vacuum is maintained, to the condenser, which it reaches a little above the boiling point temperature. It is there subjected to a rapid cooling of short duration which liquifies, but does not solidify, the metal. The temperature in the condenser is maintained between  $680^{\circ}C$ ., the solidifying temperature of magnesium, and about  $800^{\circ}C$ . The liquid magnesium drops from the condenser through a discharge tube into a receiver by gravity.

While the greater part of the dust is retained in the settling chamber, a small quantity accompanies the gas-vapour into the condenser and tends to lower the purity of the metal. This has been overcome by the simple device of allowing the liquid metal leaving the condenser to fall into an oil bath which separates any dust from the metal and permits this to be obtained as practically chemically pure. The oil bath consists of a hydrocarbon oil of low viscosity and comparatively high flame point corresponding more or less to transformer oil. The magnesium metal, in shots of 10-20 mm. diameter, is easily separated from the oil by centrifuging, and the oil in turn is freed from dust by a special method as often as necessary. This improvement is covered by Austrian Patent 140,560. It is considered that the reception of the molten magnesium in oil is of very considerable value in relation to the purity of the magnesium product.

British Patents 413,221 and 418,789 for the process cover all the essential claims in the Austrian patents mentioned.

Dr. Machu states that the problem of obtaining from magnesium oxide by the use of carbon as the reducing material electro-thermally, and the production of a pure magnesium metal in this way is satisfactorily solved after baffling researchers for many years. The process has already been well proved in a large experimental plant at Randentheim, in the Kärnten district of Austria, with the result that it is already being applied commercially.

# Surface Protection of Aluminium and Magnesium

## A New Austrian Process with Useful Features

**T**HE increasing use of aluminium and magnesium as industrial metals makes the surface protection of these metals against corroding agencies a matter of great importance. Both metals, in the pure state or as alloys, possess extremely valuable physical properties, particularly that of lightness, but are not highly resistant to attack by certain corroding influences. Aluminium, for example, is readily attacked by alkaline solutions, while magnesium is very easily oxidised. In the case of aluminium, the very thin oxide film which forms on a fresh surface of the metal, serves as a protective layer to the metal underneath and, generally, is more resistant to corrosive attack than the pure metal surface. Nevertheless, this oxide film is easily removed by even slight abrasion, and where abrasion may possibly occur the oxide film is ineffective as a means of protection.

### Electrolytic Oxidation

A comparatively recent improvement in the oxide film protection of aluminium is to oxidise the surface of the metal electrolytically, and this method is known as the "Eloxal" process which has already come into extensive use. In this process, the oxide film can be made much thicker than that obtained by atmospheric action. Moreover, it is strongly adherent, of great hardness, and consequently resistant to abrading action. It is also an excellent medium for the adsorption of colouring agents, which makes it of special value for decorative purposes. It has also been found to act as a good vehicle for light-sensitive salts and thus be of great use in the photographic industry.

An Austrian patent (No. 139,281) describes a process somewhat similar to the Eloxal process, which, besides producing the oxidised surface to the metal, incorporates other protecting substances. A brief description published in "Technische Blätter," No. 43, 1935, shows that the protective layer is obtained in two stages, and that each stage may be reached in two ways. One way is to use the aluminium to be treated as the anode in an electrolytic bath containing a 5-10 per cent. solution of sulphuric acid, using a current density of 0.7 amperes per square decimetre, with a chromate, bichromate or a silicate in the solution which become adsorbed in the oxide film. Alternatively, the aluminium metal may be immersed in a solution of 3 per cent. sodium carbonate and 0.2 per cent. potassium bichromate, at a temperature of 95° C., for 10 to 30 minutes; solutions of phosphoric acid or its salts may also be used.

### Treatment with Chromic Acid

After freeing the aluminium from solution residues by washing with water, the second stage of treatment is given, using a solution of chromic acid, potassium chromate or bichromate, or in some circumstances, sodium silicate. Here the light metal is either immersed in the solution or made the anode of an electrolytic cell. Simple immersion is best for cast aluminium or its alloys, because the rough surface becomes more uniformly treated and covered by the protective coating. If, for example, a casting of aluminium with 5 per cent. silicon is used as anode in a 7 per cent. sulphuric acid solution for 20 minutes and then, after washing, immersed for 10 minutes in a 1 per cent. solution of chromic acid, the treated metal is resistant to attack by even caustic alkali solutions. It is a special property of these protective films that they form an excellent surface for the reception of colouring agents.

The simplest method for the second stage of the treatment is to use a solution of 2 per cent. sodium carbonate and 0.5 per cent. bichromate. By immersing the metal or spraying with a permanganate solution a brown colour is given to the

oxidised surface which varies in depth according to the thickness of the oxidised coating. It is immaterial whether the permanganate solution be a saturated or a 1 per cent. solution; the oxide absorbs the same amount of the permanganate salt from each, but, naturally, more quickly from a concentrated solution.

In the same issue of "Technische Blätter," Dipl. Eng. F. Pachtner states that the corrosive action of alkaline liquids on aluminium and its alloys can be diminished or entirely prevented by adding to the liquids substances which do not react with it or otherwise change its character. In practice, it is well known that soda solutions can be used to clean aluminium vessels or surfaces if a small amount of waterglass is present in the solution, although without the waterglass the soda would be strongly corrosive. Hydrogen peroxide attacks aluminium, either by pitting or uniformly, according to its concentration, and in this case also the addition of a little waterglass is sufficient to prevent the aluminium being attacked. On the other hand, the presence of electrolytes dissolved in the peroxide, such as common salt, greatly stimulates the corrosive attack. The protective action of the waterglass is considered to be the forming of a film of silicic acid on the surface of the aluminium which protects the underlying metal.

### Protective Action of Colloids

Investigations have shown that a number of colloids also act protectively against attack of aluminium by alkaline solutions, and especially alkali carbonates. Such colloids are gum arabic, fish glue, agar-agar, starch, gelatine and size. Potassium chromate and bichromate can also be used, but require to be present in larger proportions than in the case of waterglass.

Many natural waters attack aluminium more or less and for such attack there are also protective means. Investigations into water attack on aluminium have been conducted by the Ver. Aluminiumwerke A.G., the Lautawerke, and by Röhrig and Krekeler. It has been established that salts, such as sodium chromate, or emulsified oils of certain kinds, are effective protection against water attack of aluminium. The action of the oil emulsions is that a film of oil becomes adsorbed on the surface of the aluminium. Not only aluminium, but some other metals, can be protected against the attack of corroding liquids by similar means. M. Schunkert ("Zeit. f. phys. Chemie," 1933, p. 167) found that non-electrolytes, such as starch, saponin, casein, dextrine, agar-agar, albumen and gelatine, reduce the solubility of iron and zinc in acids proportional to their adsorbing properties. On the other hand, the addition to corroding solutions of salts which strongly dissociate in solution, increases the rate of the dissolution of such metals.

THE Council of the Iron and Steel Institute announces that in accordance with reciprocal arrangements recently completed with the American Institute of Mining and Metallurgical Engineers, members or associates of the I.S.I. who are under the age of 33 and who reside in countries other than the United States, Canada, and Mexico, will be accepted as eligible for election to the newly established class of junior foreign affiliates of the A.I.M.E. The annual subscription for these junior foreign affiliates is 5 dollars (the annual subscription for full members or associates is 20 dollars, and for junior members 10 dollars); no initiation fees are payable. These reduced rates will be applicable to members or associates of the I.S.I. taking up membership of the A.I.M.E. as junior foreign affiliates, provided that they are under the age of 33 and that they do not remain in this class for more than six years.



## Some Recent Metallurgical Patents

### Hard Carbide Alloys

IN a process for making hard alloys of the type comprising two or more hard constituents such as refractory metal carbides and one or more auxiliary metals of lower melting point, each of the hard constituents is separately associated with one or more of the auxiliary metals, for example, by grinding, and the fractions so formed are afterwards mixed and sintered under pressure at high temperature. For example, 75 to 97 parts of tungsten carbide may be ground with 3 to 25 parts of cobalt, and 75 to 92 parts of titanium carbide with 8 to 25 parts of nickel; a final sintered product may then be obtained from 90 to 95 per cent. of the tungsten carbide mixture and 5 to 10 per cent. of the titanium carbide mixture. (See Specification No. 434,468, of British Thompson-Houston Co., Ltd.)

### Coating with Metals

IN the production of hydrocarbons by the treatment of carbonaceous materials with hydrogenating gases the parts of the apparatus coming into contact with the hot reagents are coated with zinc by exposing them to an atmosphere containing zinc vapour with the exclusion of oxygen and at a temperature exceeding 600° C., while passing an inert or reducing gas through the treatment vessel. Hydrogen-proof materials are used, e.g., steels, alloys containing chromium, aluminium, nickel, manganese, tungsten, vanadium, cobalt or molybdenum. The treatment may be carried out in closed vessels containing zinc which is vapourised after the vessel is closed. The air may be removed by oxidation of a part of the zinc vapour, by burning magnesium or by displacement with nitrogen or reducing gases. (See Specification No. 434,624, of H. E. Potts.)

### Alloy Steels

CHROMIUM-TITANIUM steels containing about 3 to 30 per cent. of chromium, or chromium-nickel-titanium steels containing about 3 to 30 per cent. of chromium and 5 to 35 per cent. of nickel are welded by a steel welding rod containing about 3 to 30 per cent. of chromium, 5 to 35 per cent. of nickel and a substantial amount of niobium. The rod contains carbon up to 0.3 per cent., the niobium content being preferably from four to ten times the carbon content but not over 5 per cent. The carbon content of the base metal may be up to 0.3 per cent. with titanium at least twice the carbon content but not over 5 per cent. A steel containing 18.76 per cent. of chromium, 8.88 per cent. of nickel, 0.84 per cent. of titanium and 0.12 per cent. of carbon may be welded by a steel rod containing 18.3 per cent. of chromium, 8.97 per cent. of nickel, 1.16 per cent. of niobium and 0.1 per cent. of carbon. (See Specification No. 433,585, of Electro Metallurgical Co.)

### Heat-Treating Alloy Steels

CORROSION and/or heat-resisting alloy steels containing 1 to 60 per cent. of chromium up to .25 of carbon and 0.5 to 3.0 per cent. of titanium or niobium are heat-treated, to prevent loss of corrosion resistance at temperatures below about 1,470° F., by heating to temperatures below 1,346° F. and 1,740° F. for 0.1 to 10 hours, the time being sufficient to obtain a substantial conversion of the carbon content of the steel into carbides of titanium or niobium. The steels may be heated to 2,150° F. and quenched to room temperature before the heating described above. The heat treatment may also be applied to austenitic nickel iron alloys containing chromium carbon and titanium. In an example an alloy steel containing 0.1 per cent. of carbon, about 18 per cent. of chromium, about 8 per cent. of nickel and about 0.5 per cent. of titanium is heated either for one hour at 1,600° F. or for four hours at 1,400° F. The heat treatment may be applied before or after cold rolling or fabricating. (See Specification No. 432,548, of United States Steel Corporation.)

### Magnesium

MAGNESIUM dust is wetted with hydrocarbon oils and the mixture is freed from hydrocarbons by heating preferably in an inert or reducing atmosphere; the metal is extracted from the residue by heating to about the boiling point of the metal until the particles unite in molten form, or by vaporisation and condensation, or by mechanically rubbing the mass while heated above the melting point of magnesium. The mixture of dust and oil may be compressed before further treatment, and pieces of metal in the form of rods, sheets or wire may be embedded therein. (See Specification 435,234, of Oesterreichisch Amerikanische Magnesit Akt.-Ges.)

### Aluminium Alloys

ALLOYS containing at least 90 per cent. of aluminium are prepared by adding iron and/or ferromanganese and if desired silver to part of the aluminium and the alloy containing one, two or three additions so produced is alloyed with magnesium so as to produce an alloy containing 42 to 54 per cent. of magnesium, 3 to 20 per cent. of the alloy so produced being then melted up with the remainder of the aluminium to produce the finished alloy. Alloys so prepared contain at least 90 per cent. of aluminium, 1.5 to 9.5 per cent. of magnesium and also 0.01, to 1 of iron or 0.05 to 0.8 of ferromanganese either individually or conjunctively. The alloys may also contain 0.008 to 0.9 per cent. of silver. (See Specification No. 432,964, of P. Briske, V. Prohl and A. Luschenousky.)

### Niobium-Silicon Alloys

MATERIALS containing niobium oxides are reduced with silicon or silicon alloys, such as ferrosilicon, chromium-silicon, ferrochromium-silicon, niobium-silicon, or alloys with other metals unobjectionable in the final product. The amount of silicon in the charge is preferably adjusted to yield an alloy with a niobium to silicon ratio of between about 6:1 and 12:1, in particular between 7:1 and 9:1, whereby upwards of 75 per cent. of the metal may be recovered and the niobium oxide is selectively reduced in preference to the oxides of tantalum and titanium present. Iron, nickel, chromium or other metals may be added to the product either by reducing in the presence of a metal bath or making the addition during or after the reduction. Slags obtained containing substantial amounts of niobium, tantalum, and titanium may be smelted with enough silicon to yield a niobium-silicon alloy of a less ratio than 6:1, this product then being used as a reducing agent for niobium oxide-containing material to form the lower silicon alloy. (See Specification No. 434,400, of Electro Metallurgical Co.)

### Case Hardening

IRON and steel articles are case-hardened by immersing them in a bath comprising a fused non-oxidising salt having a suitable melting point or a mixture of such salts to which has been added a suitable organic nitrogen compound, the articles thereafter, if desired, being quenched. The salt bath may comprise one or more alkaline earth salts, preferably the halides or a mixture of one or more such salts with one or more alkali metal salts, preferably the halides and/or carbonates or one or more alkali cyanides and/or one or more alkaline earth cyanides. Among the various examples of organic nitrogen compounds which may be used are arylamines, alkylamines, pyridine, ammoniated organic substances such as ammoniated peat or organic cyanogen compounds used as hydrocyanic acid or a polymer thereof, cyanamide or a polymer such as dicyanamide or organic condensation products such as melan. The organic compound may be used in solid liquid or gaseous form and the temperature of the bath used may be 500-950° C. (See Specification 434,961, of E. I. Du Pont De Nemours and Co.)

### Refining Magnesium Alloys

MAGNESIUM and high-percentage magnesium alloys are refined by melting them with a halide or sulphide of a heavy metal selected from the group I, II, V, VI, VII, and VIII of the periodic system, such metals, base metals excepted, being chosen which have a specific gravity above 6 and below 11. Magnesium halides may be used in addition to the halides or sulphides referred to. The salts or mixtures of salts must be such as have melting points below that of magnesium and a specific gravity higher than that of the molten magnesium. The salts, etc., may be melted, solidified, and the fused mass crushed before use. In one example, magnesium refined by distillation was melted with a mixture of equal parts of zinc chloride, ferric chloride, and magnesium chloride. In another example, a magnesium alloy containing 4 per cent. of aluminium, 1 per cent. of zinc and 0.3 per cent. of antimony was melted with a mixture of 40 per cent. of antimony trisulphide, 20 per cent. of ferric chloride, 10 per cent. of zinc chloride and 30 per cent. of magnesium chloride. (See Specification No. 433,859, of Oesterreichisch Amerikanische Magnesit Akt.-Ges.)

### Deoxidising Copper

IN a process for deoxidising copper by the violent intermixing of the bath of copper with a molten and fluid slag capable of absorbing the oxides contained in the metal, a metal, whose oxide has a higher heat of formation with respect to the oxygen molecule than copper oxide, is added to the bath before or during the intermixing or between two successive intermixings, the said metal reducing the copper oxide and the oxide of which is more readily absorbed by the slag than the copper oxide, the quantity of auxiliary metal added being lower than that for which the solubility at saturation in the copper of the oxide of the said auxiliary metal would be exceeded. Examples of such metals are manganese, zinc, chromium, iron, tin, lead, nickel, cobalt or magnesium and the amount used is less than 5 per cent. The slags used contain titanium oxide, and/or silica as the main constituents with alumina, lime, magnesia, sodium oxide, ferrous oxide and manganese oxide. (See Specification 430,526, of Soc. D'Electro-Chimie, D'Electro-Metallurgie, et des Acieries Electriques D'Ugine.)

## Electrolytic Recovery of Cadmium

### Utilisation of Cadmium-Containing Wastes

WHILST efforts have recently been made to introduce cadmium for different plating purposes, it is contended that a great future awaits the development of the electrolytic extraction of the pure metal itself. This is not because the demand for metallic cadmium is considerable, but because of the valuable by-products which may be recovered.

Almost irrespective of the waste source from which cadmium is obtained, the raw material is invariably rich in impurities of all kinds. When zinc is distilled from the ores, certain sections of the fume which is evolved contain the bulk of the cadmium present, whilst the purer "fume" passes on to be recovered by electrostatic methods. Much of this cadmium-containing fume has been allowed to accumulate in waste dumps as the impurities present offered many practical difficulties to direct systems of recovery, and circuitous wet processes were evolved. In the electrolysis of lead, the electrolyte remaining after recovery of the lead contains cadmium, together with other metals remaining undeposited. In the manufacture of lithopone, the tank residues remaining after the process has been completed contain cadmium with a surplus of zinc and lead compounds. Blue powder and zinc dust also contain appreciable amounts of cadmium, accompanied by all the volatile components present in the smelted raw material.

The different raw products require some preliminary treatment before they can be suitably electrolysed. The accumulated cadmium-zinc dust from the retorts where the zinc is distilled, blue powder, lithopone waste, and the precipitate obtained from the electrolysis of zinc, are in each case made into a compact mass with the assistance of a suitable binder, composed chiefly of carbonaceous matter. This mass is charged into small retorts and distilled in much the same manner as zinc is distilled. The conditions of temperature and cooling of the fume evolved have to be varied as required, otherwise the process is practically the same as the zinc distillation. The crude metallic cadmium so obtained is cast into anode plates, or discs, prior to electrolysis. This metal seldom contains 90 per cent. of cadmium; not infrequently it has only 82 per cent. The zinc content is upwards of 8 per cent., whilst copper and lead are seldom less than 1 per cent. Iron, arsenic, antimony, and even bismuth, are present in varying proportions, but seldom more than from 0.2-0.4 per cent.

For electrolysis these cast discs of crude cadmium are

placed in position in wooden vats lined with thin asphalt sheet, the rotating cathodes consisting of similar discs made from aluminium sheet. The acidity of the electrolyte was originally 5 per cent. free sulphuric acid, but this was found to lead to undue corrosion, and was later reduced to 2 per cent. The usual percentage of cadmium is about 8 per cent., but the tension will alter this appreciably, and it has been known to fall as low as 0.4 per cent. As the electrolysis proceeds the zinc tends to accumulate in the bath, and this condition can be ensured by keeping the acid concentration high. The best results are obtained by using a well cooled electrolyte throughout, which permits of working at a low current density.

When initial experiments were undertaken the electrolyte was caused to flow through a small refrigerator, but this was later recognised as being superfluous, and cold-water circulation was substituted. One method used was simply to pump the electrolyte to a series of cooling coils by means of a mercury switch arrangement. This action also added to the extent of the circulation in the electrolysis bath.

Efforts are made to maintain a bath voltage of about 3 volts, but in practice it is generally much higher than this, except where an exceedingly pure class of cadmium anode is dealt with. The discs of aluminium and the cast cadmium anodes should not be more than two inches apart, and the number of revolutions which should be made per minute to ensure compact and uniform deposits can only be found by experience. The amperage which originally was introduced at about 13 amperes is seldom allowed to exceed 8 amperes to-day. This low current density was found to be necessary to furnish the best current efficiency, and it has to be admitted that cadmium deposition has given some of the poorest results on record for metal deposition. The deposited cadmium is stripped from the aluminium discs, placed in small pots and covered with a layer of grease and melted. It is then cast in the form of small sticks.

During the progress of the electrolysis, tests are made to ascertain if valuable impurities are present, *i.e.*, selenium, tellurium and thallium. Thallium is only found in minute proportions and, after its presence has been confirmed, the spent electrolyte is removed and neutralised, and the rare metal is then precipitated by the addition of a solution of potassium chromate.







# Metallurgical Section

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February 1, 1936

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## Aluminium Silver Alloys

RENEWED interest in aluminium silver alloys is being manifested in Germany. When added to aluminium, silver normally imparts greater tensile strength and hardness, provided the proportion of silver does not exceed 5 per cent. If a particular grade of aluminium in pure condition possesses a tensile strength of 18 kilograms per square millimetre and an elongation of 3 per cent., it may easily show a tensile strength of 24 kilograms at the same elongation when alloyed with 5 per cent. of silver. By raising the proportion of silver to 10 per cent., the tensile strength is increased still further to 31 kilograms, but the elongation will then decline to 2 per cent. The alloys with 5 per cent. or less of silver are malleable, but those with about 10 per cent. of silver are brittle; because of their beautiful colour and ability to take high polish the 10 per cent. alloys, however, were at one time in demand for the manufacture of cheap jewellery. The 5 per cent. alloy has been tried in Germany and elsewhere as coin metal, as it is exceedingly resistant to atmospheric oxidation and is capable of preserving its silver colour and lustre for a long time; aluminium coins, however, ceased to be produced in Germany after the stabilisation of the national currency in 1924.

An aluminium-silver alloy with 3 per cent. of silver is already used extensively in Germany in the manufacture of industrial apparatus, especially parts of scales and balances; it has a pleasing white colour and does not corrode. Considerable interest is now being displayed in alloys containing more than 10 per cent. of silver; the brittleness of such alloys being overcome by the addition of small quantities of magnesium, varying between 0.1 and 1 per cent. This alloy is prepared by melting the silver and aluminium, then cooling the resulting liquid metal to 500°–600° C. and throwing in the desired quantity of magnesium, which is wrapped in aluminium foil to prevent combustion. The high-silver alloy is being used for the better grades of aluminium utensils, optical instruments, and special apparatus.

### Wider Uses for Nickel Alloys

A WIDER appreciation of corrosion problems in industry, the development of Monel metal with high physical properties, the perfection of the processes for cladding steel with Inconel as well as with nickel, improved colour control of nickel-silvers used for decorative purposes, and a definite advance in the use of Monel metal for household equipment have all combined to increase the importance of the nickel-bearing non-ferrous alloys during the past twelve months. The principle of permanently bonding a resisting surface to steel having been successfully demonstrated, the use of nickel and Inconel in this form has been made available for heavy equipment where the cost of a straight nickel or alloy

installation would be prohibitive. Plant used in the heavy chemical industries can now be equipped throughout with the surface most resistant to their respective types of corrosion.

Developed originally as the material for certain processes in the dairy industry at temperatures where milk is particularly sensitive to metallic contamination, Inconel has definitely broadened its uses. Containing 80 per cent. of nickel, this nickel-chromium alloy is of importance to nickel consumption. In aviation it has been adopted by many of the leading manufacturers for exhaust manifolds, cabin heaters and other parts subjected to hot engine gases. Here its controlling characteristics are its resistance to oxidation at comparatively high temperatures and its freedom from embrittlement. The availability of Inconel-clad steels has also opened up a field for the use of this material in wineries, distilleries, breweries and other industrial processes, where the value of Inconel has been established and where the clad product is especially economical for heavy construction. Inconel anchor bolts have been adopted for holding refractory fire-brick in boiler wall construction, whilst the potentialities of Inconel as a spring and screen wire have been subjected to investigation during the past year with promising results. Inconel seamless tube is finding application on high pressure steam plant, for which purpose it is available in sizes from three-quarters to one inch and lengths of 50 feet.

### Nickel Plating Progress

THE consumption of nickel in the form of anodes for electro-deposition has increased substantially during the past year. The rolled anode has now been improved to the point where it is considered to be the most uniform and highest quality nickel anode on the market. There has been a definite increase in the number of manufacturers, particularly in the motor car industry, who specify a nickel undercoating of 0.001 inch in thickness as standard for chromium plating. The development of bright nickel plating, which reduces the buffing ordinarily required in plating jobs and which speeds up the rate of electro-deposition, has shown continued interest among the larger operators, and as this method is further improved, with a consequent reduction in servicing costs, its general use will become more general. The practice of building up worn-down parts of machinery and equipment by nickel plating has also become more firmly established.

### Rare Earth Metals

ACCORDING to Information Circular No. 6847 published by the United States Bureau of Mines, the "rare earth" metals are not so rare as is generally assumed. Fifteen elements are ordinarily included in the rare

earth group, but scandium and yttrium are closely related and are usually considered with it. Industrial outlets for the rare earths do not always require the separation of the individual elements, as a "rare-earth mixture" can be employed for many purposes. The manufacture of pyrophoric alloys and flaming-arc carbons, and certain textile treatments are typical instances. Specialised uses, such as the glass industry and the manufacture of pharmaceutical products, however, require pure cerium, neodymium, or praseodymium compounds. At present "cerium," which usually means the mixture of metals in the rare-earth group, is the principal article of commerce; neodymium and praseodymium are used to some extent for optical glass and art glassware, and minor uses for lanthanum have also been developed. For the other members of the group, there are no important commercial outlets. The first industrial use for cerium was in gas-mantle manufacture; this is still an important consuming industry, although the percentage of cerium nitrate employed is small and the quantity consumed is not impressive.

### Determination of Gallium in Aluminium

COMMERCIALY refined aluminium always contains small amounts of certain impurities, among which is the rare element gallium. This metal, like only mercury and cesium, is liquid at ordinary temperatures. Its existence was first suspected by a French chemist, Lecoq de Boisbaudran, from a study of the spectral relationships of the metals of the aluminium family, and many of its properties were also described by the Russian chemist, Mendeléeff, six years before Boisbaudran actually isolated it. Gallium, however, is widely distributed in Nature being found in many zinc blendes, iron ores, and nearly all bauxites. Finding its way into metallurgical products, it causes errors in the gravimetric determination of such elements as vanadium, titanium, zirconium, beryllium, etc. In consequence the United States Bureau of Standards has recently developed two new procedures for the determination of gallium in metallic aluminium. In one case the gallium is separated from aluminium in sulphuric acid solution by precipitation with the organic reagent, cupferron, and is finally determined indirectly in an oxide mixture containing vanadium, titanium and zirconium. Alternatively the gallium is separated from aluminium in hydrochloric acid solution by extraction with ether, and is recovered by precipitation with cupferron and then determined directly as gallic oxide,  $Ga_2O_3$ .

### Extraction of Gold in Minute Amount

THE removal of minute amounts of gold and silver from sea-water was predicted by Mr. W. E. Caldwell, of the Oregon State Agricultural College in a paper read at the San Francisco Convention of the American Chemical Society. He described a method whereby as little as 1 part of gold in 4 billion parts and 1 part silver in 40 million parts can be successfully removed from a solution, quantitative recovery being accomplished by permitting a mercury-mercurous chloride residue to fall through the solution, the residue in question being produced by the reduction of mercuric chloride with powdered magnesium and acid. An assay of the residue permits the quantitative determination of gold and silver with an accuracy equivalent to the

more general cupellation procedure. It was stated that the removal of gold and silver from sea water is quite possible by such a method, but is not practical from the standpoint of cost.

### Vanadium and Titanium Smelting

METALLURGISTS in Soviet Russia are reported to have succeeded in producing vanadium and titanium of such quality and in such quantities as to make the country independent of foreign imports of these metals. Ferro-vanadium is an alloy that imparts elasticity to steel, and increases its tensile strength; titanium gives hardness and toughness to steel, and also a brilliant lustre to silver. Metallurgical difficulties were solved by the discovery that titanium ore, which contains ferro-vanadium and titanium, could be smelted in the blast-furnace. For a number of years Soviet works have been experimenting with various methods of smelting the ore, and in 1929 Professor Pavlov tried the blast-furnace method without satisfactory results. Subsequently Professor Shadlun found a way to separate the titanium from the ferrous component of the ore before smelting, and the Ural Institute of Rare Metals carried these experiments a stage further, and improved upon them.

## Scottish Steel Industry

### New Plant and Lower Production Costs

THE acquisition of practically the whole share capital of the Steel Co. of Scotland, Ltd., by Colvilles, Ltd., which was announced on January 28, seems to have been expected in the Scottish steel industry. According to "The Financial News," the movement regularises a position which has existed since Sir James Lithgow, chairman of the Steel Co., purchased control of that company in June, 1934.

Annual capacity of the combined firms is estimated at about 1,500,000 tons of steel ingots. The present combined rate of output is less than the theoretical capacity, being estimated at over 1,000,000 tons. The products consist of a full range of structural and building sections, ship and boiler plate rails, wheels, axles, castings and pig-iron. The smaller firms, of which Colvilles, Ltd., has acquired control from its controlling company, David Colville and Sons, Ltd., cover alloy steel and sheets and ingot moulds.

It is understood that a project to lay down plant for semi-finished steel at the Newton works of the Steel Co. was suspended when Colvilles undertook to lay down similar plant at Glegarnock, Ayrshire. The Steel Co. is enlarging its rail handling plant and Colvilles plan a new billet and sheet bar mill and a new rod and bar mill. Concentration of orders is designed to cheapen production costs.

### Tin Consumption Analysis

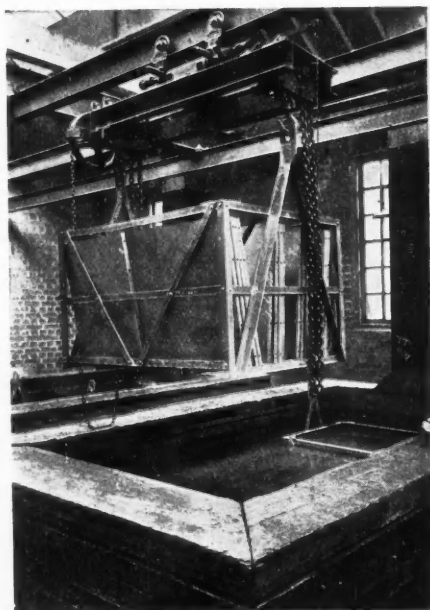
THE January issue of the International Tin Research and Development Council's Bulletin gives preliminary figures of tin production and consumption in 1935. World production for 1935 was 138,000 tons and consumption was 142,000 tons, compared with 108,637 tons and 117,681 tons respectively in 1934. Although the consumption figures show an encouraging increase of 20 per cent. over 1934, they are still considerably lower than the record level of 178,028 tons reached in 1929. The prospects for tin consumption appear favourable, for an upward trend is shown in the moving average consumption graphs of a number of important countries. Considering the twelve-month period ended November, 1935, the only country for which there is an appreciable decrease in consumption is France, and this may be due to the transfer of the Saar from France to Germany in February, 1935.



## Metal Pickling Equipment

### Advantages of Monel Metal

THE pickling of steel is undertaken to remove the annealing scale prior to enamelling, tinning, galvanising or lead-coating processes, and before cold-working, which is necessary when accurate sizes and good finish are desired in the finished product. Recent researches have shown that the scale coating consists of layers of iron oxides, the richest oxide being at the surface and the oxide lowest in oxygen content being adjacent to the base. The number of the scale layers depends on the temperatures at which the scale has been formed. Scale formed below the iron-magnetic eutectoid separation point,  $575^{\circ}\text{C}$ ., consists only of two layers, magnetic and ferric oxide. The ferrous oxide forms at higher temperatures



[By Courtesy of National Enamels Ltd.]

Monel Metal Pickling Crates have been in continuous use for several years in the factory of National Enamels, Ltd., at Greenwich. This alloy has been successfully used in contact with pickling solutions in many industries because, in addition to its good resistance to the corrosive action of the acid, it is stronger than steel and can be readily fabricated.

and the higher these temperatures are the thicker is this proportion of the scale. It is this inner layer which is dissolved by the pickling solution. As a result, the magnetic and ferric layers become detached and fall to the bottom of the tank.

Dilute solutions of sulphuric or hydrochloric acid at elevated temperatures are usually used for pickling. In both cases a restrainer is often added as a precaution against over-pickling and the consequent wastage which would result. An increase in temperature has a greater effect on the rapidity of the pickling operation than an increase in acid strength. The temperatures adhered to are usually between  $140^{\circ}\text{F}$ . and  $180^{\circ}\text{F}$ ., and an acid strength of about 5 per cent.—or possibly a little higher in the case of hydrochloric acid—is normally advisable since this strength results in a minimum of fumes and the best working conditions. For pickling iron castings hydrofluoric acid or a mixture of hydrofluoric and sulphuric acid is generally employed. The function of the hydrofluoric acid is to dissolve the sand which is embedded in the skin of the casting, or to loosen any sand cores which have not been properly “dressed.”

Pickling equipment itself must therefore be fabricated from material which is not only resistant to acid corrosion but strong enough to withstand rough usage and to support heavy weights. Wood is often used as a fabricating material for pickling equipment in the smaller establishments, but its lack of strength precludes its employment for many purposes. Cast bronzes are also used, but they seldom possess a tensile strength above 18/20 tons per sq. inch. Monel metal, however, is a material which is claimed to be very satisfactory for racks, slings, pins, hooks, crates and chains in wrought form. Apart from its high resistance to corrosion, Monel metal possesses excellent mechanical properties; as supplied for pickling plant it has a tensile strength of 35/40 tons per sq. inch.

Even in small works the initial cost of Monel metal is soon balanced by the long service which it gives, and in large works, where continuous processes for the pickling of steel sheet and cold-rolled strip are carried out, Monel metal has been widely adopted for crates, pins and lifting gear. It is also employed for yokes in pickling wire, and for chains in the pickling of tubes, while crates of the same metal are in service for the pickling of drop forgings.

## Foundry Floors

### A Unique Material for Hard Usage

OVER 30,000,000 square feet of “Stelcon” industrial flooring have been laid in works covering a wide range of industries in different parts of the world.

“Stelcon” anchor steel plates are made of steel  $\frac{1}{8}$  inch thick and are supplied in plates 12 inches square, so that



“Stelcon” Anchor Steel Plates have been used for the floor in front of this installation of Metal Melting pots.

they can be used for extensions as easily as for new installation. On the surface of each plate and on the sides, fifty-seven anchors are punched in nine different directions, so that when laid in concrete each anchor grips firmly, thus providing a level, dustless, all-steel floor of very great durability. The accompanying photograph shows “Stelcon” anchor steel plates as laid in front of the printing metal melting pots at the works of Frys Metal Foundries, Ltd., Merton Abbey,

“Stelcon” steel clad flags are made of highly compressed concrete with a specially constructed steel face. They are made in one overall size, approximately 12 inches square, half flags being supplied to enable “Stelcon” to be laid to break joint. Both types of flooring, which are supplied by Langley, London, Ltd., are becoming increasingly popular.

# Nickel and Nickel Alloys in the Chemical Industry

## Developments of the Past Year

THE further the chemical industries advance into new fields, the more dependent they have become upon materials in which strength and other physical properties are combined with resistance to corrosion. In this development nickel, nickel-clad steel, Monel metal and Inconel have extended their usefulness, according to a statement made in the annual survey of the nickel industry in 1935 by Mr. Robert C. Stanley, president of the International Nickel Company of Canada, Ltd.

The manufacture of caustic soda is now a well established industry, and here nickel, in its rolled and clad forms, is being used in larger volume in the manufacture and handling of the product. A new use for Monel metal is in the tanning of high grade leather. A preliminary operation is the processing of skins with a sulphuric brine solution in large revolving drums. The drums have usually been made of wood. Because rejections were running as high as 10 per cent., one manufacturer tried lining a drum with Monel metal; rejections were eliminated and the quality of skins improved, and he estimated five days' operation paid for the lining. Monel metal drum hoops and bolts have also proved satisfactory.

Monel metal is acknowledged a durable and economical material for many items of salt processing equipment. Nearly every important salt producer uses Monel rotary salt driers, and many have Monel centrifugal extractors, conveyors, washing tanks, dissolving tanks, filters, hoppers, chutes, grainer troughs and parts, perforated screens, utensils, accessories, etc.

### Fatty Acid Production

The desire of manufacturers of fatty acids to produce a product of the utmost whiteness and purity has caused further acceptance of corrosion resisting alloys. The same may be said of manufacturers of quality soaps, fancy cosmetics and pharmaceuticals who require fatty acids as their basic raw material and also have the problem of purity and colour. Continued progress has also been made in equipment for the continuous distillation of fatty acids. Monel metal is being introduced for piping, valves, bubble tray support and bubble caps because of its resistance to corrosion and strength at high temperatures. Inconel is being used for continuous heaters and vacuum bubble towers.

With the growing use of non-combustible synthetic solvents for dry cleaning, the high initial cost of these products has stimulated installation of recovery apparatus. Owing to the highly corrosive nature of the solvents, corrosion resistant materials are required. Leading manufacturers of dry-cleaning apparatus are now specifying Monel metal as standard for solvent reclamation systems handling carbon tetrachloride and other chlorinated solvents, as well as for filter elements in pressure filters handling such common petroleum solvents as gasoline, benzene and naphtha. The trend is toward the use of Monel metal not only for the large installations in dry-cleaning plants and laundries but also for the units sold or rented to small dry-cleaning shops.

### Zinc Chloride Evaporation

Numerous tests have shown Monel metal to be well suited for coils in zinc chloride evaporation. It has been successfully used for this purpose for more than a year. Monel metal is also being used in a large plant manufacturing copper sulphate for agricultural purposes. Monel metal screens are employed in grading the washed crystals and in the baskets of the centrifuge in which the remaining mother liquor is washed from the crystals with water. Tests in operating equipment have led to the use of Monel metal heating coils in a sodium sulphide evaporator.

The use of nickel and nickel-clad steel in the production of synthetic phenolic resins has increased steadily because

of the demand for a material which will not affect the delicate colours of the product. Nickel is useful for the equipment in which the reaction takes place, and nickel-clad steel for tanks and tank cars in which the phenol is stored and transported. The use of pure nickel for paraffin chlorinators, where the metal must resist the action of petroleum hydrocarbons and moist chlorine gas, is increasing. Pure nickel has also been shown to be resistant to concentrated ammonium chloride.

There has been a steady expansion of the use of nickel in the viscose rayon industry which demands freedom from metallic contamination. Here nickel is used for vacuum crystallisers in the recovery and concentrating of chemicals from coagulation bath liquor.

### Pipes for By-product Liquors

Ni-Resist increased its usefulness in many of the chemical process industries, including oil, coke, gas, salt, soap, paper, edible oils, fatty acids, and textiles. Castings of 5 and 10-ton weights are regularly employed for large pumps, still parts, filters and condensers. Ni-Resist pipe produced by the deLavaud centrifugal process is now available on a commercial basis. This opens up a market for the handling of corrosive industrial waste and by-product liquors. Ni-Resist has also made progress as a material for sewage disposal equipment and has proved to be superior to ordinary iron for vapour boxes and charging doors in garbage disposal plants.

After more than a year's use, Inconel has proven its superiority in the construction of screens for drying gelatin used in the food and adhesive industries. Inconel offers complete freedom from contamination and discolouration of the product and resists the severe service of heating off the dried gelatin. The use of Inconel for photographic hypo-fixing tanks is increasing in the moving picture industry.

At sub zero temperatures range at which dewaxing of lubricating oils is now carried out, the impact value of carbon and many alloy steels decreases to a marked extent. However, those containing 2 to 5 per cent. of nickel retain a good part of their room temperature impact resistance in this range. Hence there has been a widespread adoption of nickel steels with low carbon content for large vessels used in the dewaxing of lubricating oils.

## Tin Coatings on Copper

### Cause of Striations

THE International Tin Research and Development Council has just issued a reprint of the paper on "Striations in Tin Coatings on Copper" which Dr. Bruce Chalmers and Dr. W. D. Jones contributed to the "Transactions of the Faraday Society," September, 1935.

Under certain conditions of tinning, striations are plainly visible to the naked eye across strips of copper which have been allowed to cool from one end so that crystallisation occurs uniformly in one direction. In ordinary practice the irregular cooling of the coating prevents the striations occurring in a regular and obvious pattern, but they then form concentrically about the nuclei of crystallisation. Under a low-power microscope the pattern is seen to consist of alternate smooth and mottled surfaces across the single crystals of tin. It is shown that the effect is due to the crystal facets being inclined to the surface in a periodically varying manner within the single crystals of tin. Examination of a number of specimens by optical and metallographic methods shows the phenomenon to be related to the crystallisation of the tin and copper-tin eutectic.

## The Platinum Industry in 1935

### New Outlets for Platinum Catalysts and Chemical Plant

WHILE it is too early to compile precise figures to illustrate the progress of the platinum metals in the year 1935, it can be definitely stated that consumption of these metals confirms the revival of all of the industries in which they are used, states Mr. Charles Englehard, of New York, the leading authority on platinum metals in the United States.

Developments during the latter part of the year were particularly significant. Through July consumption was normal, but in August there was a relatively large increase in demand, which continued at a higher level not only than the preceding months but than the corresponding months of 1934. Canada continued as the leading producer, being followed in order by Russia, South America and South Africa. Consumption of all platinum metals, including palladium, will during the year probably total close on 275,000 ounces.

#### Improvement in Jewellery Trade

Part of the increased consumption may be attributed to improvement in the jewellery trade. Evidently by mid-summer the trade became convinced that the winter market for fine jewellery was likely to reflect other signs of better business conditions, and sustained buying indicated that this opinion was reinforced as time progressed. Thus the usual seasonal increase which ordinarily occurs in August was larger than in 1934. A curious twist of fashion has decreased the total amount of white metal jewellery while increasing the demand for platinum and palladium by the jewellery trade. This is because white gold and cheaper white materials are being less used, but the precious white metals are in increasing demand. This is attributed to a desire on the part of the public to avoid ornaments which seem to pretend to be something they are not. If gold is to be worn it must be golden, and if a white metal, then it must be real platinum or palladium.

The continued activity of the chemical industry has led to several new developments and to further outlets for platinum catalysts and laboratory equipment. Platinum-clad material for chemical apparatus is again being discussed in the industry. This follows closely the introduction of nickel and other clad materials. There appears to be no reason why industry should not avail itself of the corrosion-resistant properties of platinum in this economical form.

#### Platinum in Dentistry

In dentistry the use of platinum and palladium alloys continues to grow. To the aesthetic advantages of their neutral colour are added the sanitary considerations of surfaces which are non-tarnishing and easy to clean. In addition, careful consideration by members of the dental profession of the qualities of precious metals has led to a further appreciation of the properties of platinum and palladium and their alloys. Restorations made of these metals are not so hard that they will crack or erode natural teeth, and, in addition, since they can be worked by the dentist after they are made, they can be made to fit perfectly.

Rhodium found increasing use as a finish for reflectors and for the protection of silverware from tarnish. Establishments were opened in New York, Philadelphia and Chicago for job plating of rhodium, and "rhodanising" of decorative silver pieces is being offered as a service by leading department and jewellery stores throughout the United States.

A new field for research in platinum came to international attention toward the close of the year, with the successful production in the United States of a platinum flute. Made entirely of iridium-platinum, the flute is claimed to have greater purity of tone and ease of performance than any instrument so far made of other materials. Some years ago

Professor D. G. Miller, of the Case School of Applied Science, advanced the theory that the denser the material of which a flute is made the better the tone produced will be. This theory was confirmed by preliminary research with flutes of gold, silver and other materials, but only recently has research been applied to platinum, the densest material so far used. Statements of both musicians and scientists indicate that, while the preliminary conclusions are accepted, representatives of both fields are anxious to carry the investigation further.

Industrial uses of the platinum metals continue to advance or hold their own. Among those trades in which platinum has become well established are the rayon manufacturing industry, which uses platinum-gold spinnerets for handling caustics, and the electrical field, where platinum points in magnetos provide a high degree of reliability for aeroplane motors and the like. Palladium leaf is finding wider acceptance in diverse fields ranging from pure decorative art to bookbinding. A number of artists have used palladium leaf as a white material comparable to gold leaf in screens and panels, and a method for applying coloured pigment to the metal surface has been developed.

## United States Zinc Industry

### Advance Statistics for 1935

PRELIMINARY statistics on the United States zinc industry in 1935 indicate a number of favourable factors in the domestic situation. Production of metal from domestic sources increased about 16 per cent., but apparent domestic consumption was at a rate approximately 32 per cent. higher than in the preceding year, and stocks of refined zinc were substantially reduced. On November 30, 1935, stocks of zinc at smelters were only 55 per cent. of the record high stocks on hand at the end of 1930 and were the lowest recorded since the end of 1929. Production of metal from foreign ores and concentrates was relatively the same as in 1934, while production of secondary distilled zinc increased considerably, following a large decline in output of this class in 1934.

Figures for the first eleven months of 1935 indicate that imports of slab zinc for consumption were the largest recorded since 1921, while exports of zinc will doubtless show a decrease of 25 per cent. in 1935. Exports in 1935 will probably be less than 15 per cent. of the annual average for the period 1925-29. The output of primary metallic zinc from domestic ores in 1935, as reported by producers from figures of actual production for eleven months and estimates for December, was about 411,500 short tons, an increase of 16 per cent. over the 355,366 tons produced in 1934. Production in 1934, in turn, was 16 per cent. higher than in 1933. Over 8,400 tons of zinc were produced from foreign ores in 1935, compared with 8,224 tons in 1934.

In addition to the output of primary zinc, about 27,900 tons of re-distilled secondary zinc were produced as compared with 19,691 tons in 1934. Thus the total supply of distilled and electrolytic zinc in 1935 was about 447,800 tons, including 156,200 tons of high grade metal. Of the total output of primary material in 1935, about 118,500 tons were electrolytic zinc.

A total of about 70,900 regular horizontal retorts was reported at the 13 zinc smelters that operated during all or a part of the year. Of that number, 34,300 retorts were reported in operation at the end of November, and 35,900 were expected to be in operation at the end of the year. At the end of 1934, 33,231 retorts were in operation.



## Some Recent Metallurgical Patents

### Silicon Iron Alloys

ACID-RESISTANT silicon iron castings are produced by melting pig iron in a shaft furnace, etc., adding silicon or ferro-silicon to the molten mass, removing the graphite which separates from the molten mass, adding, in the solid form, low-carbon iron, low-carbon ferro-silicon of low silicon percentage or a mixture of low-carbon iron with silicon or ferro-silicon and finally casting the finished alloy in moulds. Only sufficient silicon or ferro-silicon may be added initially to cause the separation of the graphite, the rest being added after the graphite is removed. The silicon or ferro-silicon may be added to the molten pig iron outside the furnace, etc., in which the latter is melted. Other metals such as nickel or copper up to 3 per cent. may be included in the alloys. The upper limit of the silicon content is 25 to 30 per cent. (See Specification 434,847, of Isabellen-Hütte, Ges.)

### Cementation and Refining

ARTICLES, such as connecting pieces for pipe-lines, which can be welded satisfactorily and having a wall thickness of one inch or less are manufactured from malleable cast iron produced by imparting a ferritic or pearlitic structure free from temper carbon to castings containing 2.2-3.2 per cent. of carbon, less than 0.6 of silicon, 0.15-1.2 of manganese and less than 0.1 of sulphur by subjecting them to an oxidising annealing treatment at below 950° C., in which no free graphite is formed, and the carbon is directly removed from the cementite. The amounts of the silicon and sulphur are preferably maintained in certain specific ratios to one another. The raw materials are melted in a reducing furnace in an electric, reverberatory or drum furnace and during or subsequent to the melting, deoxidised by aluminium, manganese, etc. (See Specification 434,846, of K. Roesch and O. J. Schleimer.)

### Refining Aluminium

IN a process for treating molten aluminium and its alloys prior to casting, the metal is agitated by any suitable means while maintained in an atmosphere free from hydrogen, water vapour or other hydrogen gas supplied to the space above the metal, the surface of the metal, etc., being simultaneously treated with a flux capable of dissolving any oxide present or formed during the process. The atmosphere may consist of dry nitrogen, carbon monoxide or carbon dioxide and a flux used consists of a mixture of 50 parts of potassium chloride, 40 parts of sodium chloride and 10 parts of sodium fluoride. The agitation may be effected by mechanical stirring or by treatment in a high frequency furnace. One example of an alloy contains 4 per cent. of copper, 2 of nickel, 1.5 of magnesium and the balance aluminium. (See Specification 435,104, of British Non-Ferrous Metals Research Association, D. Hanson and I. G. Slater.)

### Improved Malleable Iron

THE physical properties of malleable and grey cast iron are improved by the addition of 0.25-3 per cent. of copper, 0.05-0.5 per cent. of titanium and optionally 0.015-0.15 per cent. of aluminium. High strength grey cast iron is made by using metal suited to the production of malleable cast iron, and by making additions to produce, by a treatment shorter than the usual annealing process, a grey cast iron. The copper and aluminium are added either in their single unalloyed state or combined in the form of alloys and the titanium can be added as an alloy such as ferro-titanium. For the production of malleable cast iron, the silicon or carbon content should be reduced to prevent the formation of primary graphite, but in the case of grey cast iron these contents should be increased, and the carbon or silicon content, or both, adjusted according to the section of the article to be cast. (See Specification 435,656, of Crane, Ltd., and H. H. Shepherd.)

### Surface Treatment of Aluminium

ALUMINIUM or an aluminium alloy is coated with an oxide layer by chemical treatment in a bath to which is added a substance having capillary activity. The bath may consist of 50 gm. anhydrous soda, 15 gm. sodium chromate and 15 gm. sodium isopropyl naphthalenesulphonate per litre of water; the bath is employed at 40-100° C. The process enables preliminary cleaning to be dispensed with. The layers may be readily dyed. (See Specification 436,704, of Peintal Soc. Anon.)

### Hardening High-Speed Steels

GREAT hardness is produced in high-speed steels containing in addition to iron, 0.1-3.0 per cent. of beryllium, 0.2-2.5 of carbon, 12-25 of tungsten, 0-17.5 of molybdenum and 0-7.5 of vanadium by quenching from 1,100-1,350° C. and then ageing or annealing at 400-700° C. The steels may also contain about 3.5 per cent. of chromium and about 3-15 of cobalt. In an example, a high-speed steel containing 18 per cent. of tungsten, 4 of chromium, 0.8 of carbon, 0.2 of manganese, 0.2 of silicon and 0.6 of beryllium is quenched in oil from 1,320° C. and annealed at 500° C. for an hour. (See Specification 435,552, of Heraeus Vacuumschmelze Akt.-Ges., and W. Hessenbruch.)

### Fluxes

LIGHT-COLOURED leaded ammonium chloride crystals, suitable for use in soldering and tinning, are obtained by causing mixed crystals of a lead compound, *e.g.*, lead chloride, and ammonium chloride, to be deposited from an alkaline solution of ammonium chloride containing lead and treating the crystals so deposited with acid, preferably hydrochloric acid. The treatment may be effected by acidifying the mother liquor in which the crystals are suspended and then separating the crystals, by treating the separated crystals with an acidified ammonium chloride solution or by treating the separated crystals with a dilute and, *e.g.*, sulphuric or hydrochloric acid. The mixture of acid liquor and crystals may be agitated with compressed air before separating the crystals. (See Specification 436,886, of Grasselli Chemical Co.)

### Beryllium Alloys

IN a process for making beryllium alloys by the reduction of reducible beryllium compounds by an alloy of magnesium with the metal less electropositive than beryllium, which it is desired to alloy with beryllium, alkali double fluorides are used containing less alkali fluoride in proportion to the beryllium fluoride than is indicated by the formula  $\text{BeF}_2 \cdot 2\text{NaF}$ . Examples of such metals are copper, aluminium or zinc. An alloy of zinc and beryllium thus obtained may be re-melted in a flux of equal parts barium chloride and fluoride, to distil off the zinc and leave molten beryllium. Beryllium alloys may be formed with any metal that is capable of alloying with zinc and not volatile at 1,300° C., for instance, iron or nickel. For example, a zinc alloy containing 17.1 per cent. magnesium and 6.13 per cent. iron is melted in a crucible with  $\text{BeF}_2 \cdot \text{NaF}$  resulting in a yield of a zinc-iron-beryllium alloy containing 7 per cent. beryllium and 7 per cent. iron, with 1 to 3 per cent. magnesium. This alloy is heated to 1,300° C. in a suitable flux and yields an alloy containing 50 per cent. iron and 50 per cent. beryllium. A copper-beryllium alloy containing 12 per cent. of beryllium is obtained by adding a copper-magnesium alloy containing 26.7 per cent. of magnesium to  $\text{BeF}_2 \cdot \text{NaF}$  in a crucible heated to 1,000° C., from which is poured a copper alloy containing 11 per cent. beryllium and 3 per cent. magnesium, the latter alloy being re-melted to get rid of the magnesium. Alloy of iron and nickel containing about 50 per cent. beryllium are also referred to. (See Specification 435,747, of Compagnie de Produits Chimiques et Electrometallurgiques Alais, Froges, et Camargue.)

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# Metallurgical Section

March 7, 1936

## Corrosion of Aluminium Alloys

At the 5th Corrosion Congress recently held in Berlin, Dr. Zurbrugg, of Switzerland, reported some interesting corrosion experiments carried out with pure aluminium and aluminium alloys. A number of specimens were tested for six months in distilled water, tap water, sodium chloride solution (3 per cent.), and synthetic sea-water, three conditions—(a) still; (b) aerated; and (c) bubbled with carbon dioxide—being observed at a temperature of 20° C. In each case the amount of corrosion was estimated from the appearance of the metal and the decrease in tensile strength and elongation. With 99.3 per cent. aluminium the effect of the carbon dioxide was noticeable only in the case of distilled water; with 99.8 per cent. aluminium the effect was apparent in all four liquids. Corrosion in the presence of carbon dioxide was particularly large in the case of aluminium-magnesium-silicon alloys immersed in distilled water; aluminium-manganese and aluminium-magnesium-manganese alloys of the non-ageing type were only noticeably attacked in the liquids through which carbon dioxide was bubbled, and even then the corrosion commenced at the cut edges of the metal. With an alloy of aluminium, copper and magnesium the increased corrosion due to carbon dioxide was noticeable only in the case of sea-water immersion.

### Non-Metallic Inclusions in Aluminium

DISCUSSING the influence of non-metallic inclusions upon the corrodibility of aluminium in a recent paper (Norges Tekniske Høiskole, 1935), L. Tronstad stresses the point that corrosion resistance may be lowered by imperfections in the natural oxide film caused by the actual inclusions or by the oxide film being broken by gases which are evolved from the action of water on these inclusions. He also states that the anodic leakage of current can be used as a measure of the imperfection of the oxide film, as the inclusions generally show cathodic behaviour and the aluminium is consequently attacked.

Among the most common non-metallic inclusions found in aluminium and their effect on the metal, Tronstad points out that aluminium oxide can affect both chemical and physical properties. The inclusion of graphitic silicon seems to have little or no connection with corrodibility, but coarse silicon may easily cause imperfections in the oxide film and so influence the corrodibility indirectly. Nitrides, which are formed during hot working, seem to be confined to the surface of the metal, but are rapidly decomposed by moisture, as only traces could be detected on the surface of the sheet metal. Sulphides, phosphides, and carbides, have effects which are similar in that such inclusions occurring at the surface of the metal give rise to gases when in contact with moisture and the protective oxide

film is thereby broken. In commercial sheet aluminium of 99.6 per cent. purity, carbide inclusions are of rare occurrence, phosphorus is present to the extent of less than 1 part per million, sulphur may vary from 0.2 to 0.9 parts per million.

From the corrosion aspect sulphide inclusions at the surface of the metal are of special importance. Aluminium sulphide is readily formed at high temperatures from other sulphur compounds, and this sulphide, in turn, forms solid solutions with aluminium oxide which separate in the form of globules on cooling. These superficial inclusions easily react with moisture if the sulphide content is high, and the resulting hydrogen sulphide gas breaks the oxide film. When the sulphide content is low, gas is not evolved to any appreciable extent. Such superficial sulphide inclusions can be detected by the use of silver bromide photographic paper. The metal is first very carefully degreased, and the silver bromide paper moistened with distilled water is then pressed in contact with the metal and kept under pressure for a period of ten hours. When subsequently bleached and fixed in a neutral fixing bath, the sulphide spots will remain blue black and any phosphide spots will become yellow. Tronstad reports that only about 20 per cent. of these sulphide spots are anodically active.

### Aluminium Foil and Leaf

ALUMINIUM foil and leaf now constitute one tenth of the German output of aluminium, the foil being used in place of tin-foil for packing various foods. In rolling the metal, it is said that there is considerable hand labour and spoilage, especially for leaf. Sheet aluminium becomes "foil" when its thickness falls below 0.1 mm., but the range is 0.1 to 0.001 mm. "Leaf" is thinner than 0.001 mm. and is made by a process of hammering, as in the case of gold leaf.

For foil, ingots should contain 99.2 per cent. aluminium, and in casting them care must be taken to avoid occluded gases. The re-heating of the ingot after casting is said to be advantageous. The first stage of the rolling is done at a temperature of 420° C., which is observed by means of a surface pyrometer. The plate is then cut into four strips and annealed at 420° C., after which it is cold-rolled in three stages to the thickness of sheet metal, and in six subsequent rollings the thickness is reduced to 0.04 mm. From this point, the sheets are handled in the foil-making machinery, bands as long as 1,000 metres being rolled by continuous operation. The foil is finally heated at 500° C. to make it pliable and to burn off dirt and grease.

In making leaf, 500 sheets of foil 0.04 mm. thick and 1 metre long are piled, annealed, and beaten with a pneumatic hammer until the average thickness is 0.03 mm. Two such piles are then superimposed and

beaten to 0.02 mm., two piles of 1,000 sheets are combined to produce sheets 0.01 mm., and this operation is continued until the desired thickness is attained. Only one third or a little more of the original aluminium produces marketable goods by this method, the remainder being damaged while separating the leaves. The effect of hammering is lessened by placing the piles of aluminium between two sheets of zinc.

### Scaling of Iron and Steel

THE scaling of iron and steel during heat treatment and hot working is discussed in a recent issue of "The Metallurgist," published as a supplement to "The Engineer" (December 27, 1935). This subject is one of importance to all iron and steel using industries, because the phenomenon takes place wherever iron or steel is used at elevated temperatures. It has definite ill-effects other than surface defects, in addition to causing loss of metal, partial decarbonisation of carbon steels being one instance. The mechanism of scaling has already been elucidated by a number of investigators, among whom U. R. Evans and L. B. Pfeil, may be specially mentioned. In the absence of complicating factors the rate of oxidation follows a parabolic law, the iron diffusing outwards through the oxide film, whilst the oxygen diffuses inwards. In the oxide scale three distinct layers have been identified, in which there are up to four phases of iron in various degrees of oxidation. In the case of alloy steels the mechanism is complicated by the fact that one of the alloying elements generally shows a greater tendency to oxidise, as evident from its more rapid rate of diffusion through the scale. Alloys of iron and aluminium give two distinct types of scale according to the rate of oxidation, aluminium content and temperature at which the alloy is exposed to oxidising conditions. At a very slow rate of oxidation, alloys with high aluminium content give a fine white powder which has proved to be aluminium oxide; as the aluminium content decreases, the colour of this powder changes to red.

### Recent Developments in Cast Iron

THE volume of research work now being directed towards the improvement and utilisation of cast iron inevitably becomes published in a heavy batch of literature. A comprehensive summary of some of the more important investigations is published from time to time in "Stahl und Eisen." The winter issue of "Metal Treatment" contains an abridged translation of the German review published in November, 1935, which contained references to eighty original papers. Here a condensed summary is given of scaling tests on Ni-Resist, durability tests on nickel alloy cast iron firebars, experiments on the modification of properties produced in 1 per cent. nickel, 0.35 per cent. chromium cast iron by heat-treatment, depth-hardening experiments on alloy cast iron of varying nickel content, and experiments on nickel-chromium cast iron crankshafts. Other sections of the paper deal with melting and casting technique, the nature of the surface skin on iron castings, tests for cast iron, moulding materials, and the addition of copper, molybdenum, tungsten and other alloy elements to various types of iron.

A problem of major importance in cast iron foundry practice consists in the production of castings which are hard but machinable, and which can be easily fitted to precise dimensions. Plain grey or white irons are

inadequate for this purpose, since the types which are readily machinable in the "as-cast" state are unsuitable for quenching in water or oil, and their response to heat-treatment is usually insufficient to permit of air-hardening, while the white irons (which have a high hardness "as-cast") and machinable only with difficulty. A satisfactory solution of this problem has been found by the development of an alloy iron of a composition such that in the "as-cast" state the material is austenitic and consequently machinable, while after machining it may be transformed by heat-treatment into a martensitic structure giving the desired hardness. A systematic study of the combined action of nickel and manganese has recently revealed that these conditions are met by an alloy iron containing total carbon 2.65, graphitic carbon 1.65, combined carbon 1.00, silicon 1.8, phosphorus 0.074, sulphur 0.025, manganese 3.75, and nickel 6.5 per cent.

### Raw Material for Beryllium Alloys

THE use of beryllium-copper is steadily increasing and the leading metallic beryllium producer in America has now started up a new plant at Temple, Pa. The direct production of beryllium-copper and other beryllium alloys, which for some time have been made by electrolysis without passing through the pure metal stages, offers much hope for a substantial decrease in the price of these alloys. Recent outstanding developments in the use of beryllium-copper include heavy duty bearings and moulds for use in the plastics industry. Potential supplies of raw material have checked the progress of this industry, but new sources of beryl are encouraging; to a considerable extent the 1935 supplies came from British India, although Brazil, Argentina and South Africa were important sources. Beryl of United States origin now appears to be susceptible of a large increase in production at the mines. Germany continues to be the leading producer of the metal outside the United States; Italian interests are said to have been contemplating the development of African ores, as well as the utilisation of home supplies, the latter being of little consequence. In Canada, where beryl occurs in large deposits, possibly more difficult to work, the 1935 production was unimportant.

### Purification of Metallic Gallium

FRACTIONAL crystallisation as a means of purifying material does not hold good in the case of metallic gallium. It has been found that if gallium, containing such impurities as antimony, silver, gold, bismuth, cobalt, chromium, copper, mercury, iron, manganese, molybdenum, nickel, osmium, lead, palladium, platinum, rhodium, silver, tin, thallium, vanadium, and zinc, is subjected to fractional crystallisation, the impurities named tend to concentrate in the crystalline portion, with the exception of silver, mercury, lead and tin, which are concentrated in the molten residue; copper and thallium remain about equally divided between crystals and residue, and zinc is dissolved by the hydrochloric acid under which the crystallisation takes place and is entirely eliminated. At the United States Bureau of Standards it has also been shown that separation from iron or platinum in excess of 0.001 per cent., from indium or lead in excess of 0.01 per cent., or from tin in excess of 0.02 per cent. by fractional crystallisation of the metal is impracticable.

# Welding Chromium Steels in Chemical Plant Equipment

By J. R. DAWSON\*

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**C**HRONIUM steels have been grouped in various ways and probably the most useful arrangement from the standpoint of composition, fabrication, and use, is as follows:

Group.	% Chromium.	% Carbon.	% Nickel.
1	12.0 — 17.0	over 0.20	
2	11.0 — 14.0	less than 0.12	
3	15.0 — 18.0	less than 0.12	
4	20.0 — 30.0	less than 0.30	
5	17.0 — 25.0	less than 0.20	7.0 — 12.0
6	7.0 — 25.0	less than 0.20	17.0 — 22.0
7	Castings—considerable variation of composition.		

Although the stainless steel of Group 1, which is relatively low in chromium and high in carbon, is seldom welded, the steels of the other groups may be fabricated or repaired by fusion welding either by the oxy-acetylene flame or the electric arc.

## Correct Type of Welding Rod

In oxy-acetylene welding, the welding rod chosen should be of the same composition as the material being welded. There are certain instances in which the low carbon chromium-nickel welding rods may be used for welding the alloys that contain only chromium, but this should be done only after assurance has been obtained that the weld metal from the nickel-containing rods will be suitable for the service that is to apply to the chromium steel. It is often customary to choose for welding rods, steels that have carbon on the low side of the specification and chromium, and nickel if present, on the high side so that if during welding there is a slight increase of carbon or loss of the corrosion-resisting elements, that final weld metal will have a composition well within the requirements of the specification.

A welding flux is required for maximum success with the oxy-acetylene process. Ordinarily this flux is painted along the edges to be joined, as well as on the top and especially the bottom surfaces for the length of the seam. The stainless steels conduct heat less readily than ordinary steels and it is important to avoid overheating the weld. Therefore the flame chosen for joining stainless steels should be smaller than that used to weld ordinary steel of the same thickness.

## Flame Conditions in Welding

The properties of welds in stainless steels are greatly affected by the type of flame employed. The flame should be adjusted to give "neutral" conditions in which equal volume of oxygen and acetylene are consumed. Its regulation is understood and is made without difficulty by those experienced in oxy-acetylene welding. If more acetylene is used than is needed, a luminous envelope is formed around the main conical portion of the flame. This is called an "excess acetylene" or reducing flame and causes the absorption of carbon in the melted weld metal, which in most instances leads to decreased ductility in the weld and especially to less effective corrosion resistance. The increase of carbon, often referred to as carbon pickup, is practically negligible when the neutral flame is employed. If the flame is given too much oxygen, the molten surface of the weld metal becomes oxidized causing the production of an extremely infusible slag which leads to the formation of blowholes and the trapping of impurities in the weld.

In most instances sheet 1/16 inch or less in thickness are flanged at the edge to a height of about 1/16 inch. The flanged edges are painted with the flux at both the top and bottom and are held in place as the flame melts down the flanges to form a smooth moderately re-enforced weld.

Slightly heavier sheets up to 1/8 inch in thickness may have the edges butted and welded with some addition of metal from a welding rod. A backing strip, generally of copper, is used beneath the joint to prevent the liquid metal from flowing out of the weld. Plates heavier than 1/8 inch are scarfed at the ends to provide a vee so that fusion entirely to the bottom of the weld will be easily obtained. The filling material for these welds is supplied by welding rods.

## Useful Welding Hints

It has been found helpful to place the parts being joined so that the line of weld inclines slightly downward in the direction of the welding. This permits the flux, which fuses at lower temperature than the steel, to flow forward and constantly provide protection for the metal as it fuses. Welds in stainless steel are almost always made entirely from one side, and care is taken to completely fill the seam so that there will be no occasion to return to some point that should have been finished as the weld progressed. If this does become necessary, or if there is need for welding at the back-side of the seam, severe stresses will be produced unless the entire seam is preheated before the flame is applied to a local area of the joint. Such pre-heating frequently is undesirable because of the likelihood of warping and because slow cooling is harmful to some of the steels. It appears justifiable to refer once more to the flux used for oxy-acetylene welding. A special flux which has the property of dissolving chromium oxide is essential to success. The fluxes ordinarily used for bronze welding or welding cast iron are not satisfactory.

In most respects the procedures necessary to obtain good results in the arc welding of plain carbon steel should also be employed for the stainless steels. When high chromium steels are melted they have great affinity for oxygen, and the various electrode coatings that are used serve to protect the melted weld metal from contact with the atmosphere and maintain a steady arc. There is a wide variety of coatings in use and most of them contain deoxidizing materials, such as ferromanganese which aids in removing oxides from the melted metal and in the production of sound welds. The stainless steel metal of the electrodes may contain various elements that are essential to give the weld the properties desired, and the coatings should be of a composition that will encourage the retention of these beneficial elements in the metal as it passes from the electrode to the weld.

## Electrodes and Polarity

Since the stainless steels are high in resistance to flow of heat and electricity, and low in melting point as compared with ordinary steel, generally a smaller electrode will be used than is chosen for welding a given thickness of ordinary steel and the current and voltage should be less than for a steel electrode. In practically all instances arc welding is carried out with reversed polarity, i.e., with the electrode made the positive pole. For quality in arc welding the edges to be joined must be cleaned thoroughly before the welding is started and if more than one layer or bead of weld metal is required, the slag on the surface of each layer applied must be completely removed. This slag may be broken by light blows with an air hammer and the cleaning should then be finished with a wire brush.

As previously stated, the steels of Group 1 that contain 12 to 17 per cent. chromium and over 0.20 per cent. carbon are often referred to as the cutlery type of steels. The stainless properties depend not only on the correct chemical composition but also upon heat treatment and a polished condition of the finished surface. The surface is affected and the properties altered by welding, which makes this material

\* A paper published by the United States National Safety Council.



extremely brittle both in the weld and in the adjacent zone. As a result, steels of this group are generally not welded.

The weld metal and the adjoining base metal of Group 2 steels, carbon less than 0.12 per cent., chromium 11 to 14 per cent., are subject to air hardening when heated to the high temperatures required for welding. These welds may be greatly improved by annealing at temperatures of 1,200° F. to 1,400° F. The treatment is applied most effectively in a furnace, but when furnace annealing is impractical good results can be secured by reheating with the welding flame. If the weld is heated and maintained for two or three minutes at a dull red temperature, the hardness and brittleness will be reduced substantially.

#### Enlarged Grain Condition

The steels of Group 3 contain 15 to 18 per cent. chromium and less than 0.12 per cent. carbon. These steels are more resistant to a variety of corroding media than the steels of Group 2, which are lower in chromium, but their main use is for resistance to oxidation and chemical corrosion at normal and temperatures up to 1,500° F. Some of the steels within this range contain about 1 per cent. silicon which is of particular benefit in oxy-acetylene welding because of the improvement in the flowing qualities. Welds in this material are subject to brittleness and to grain growth in the metal adjoining the weld, but by the low temperature annealing already described, the strength and ductility may be restored.

The steels of Group 4 contain chromium from 20 to 30 per cent. and are used mostly to resist corrosion and oxidation at very high temperatures. These steels have greater general resistance to chemical corrosion than those of lower chromium content. Although weld metal and metal adjacent to the weld are not hardened by heating to the welding temperatures, welding causes grain growth with resultant weakness and brittleness at the joint. This enlarged grain condition cannot be removed by heat-treatment, although appreciable ductility may be imparted to the welded structure by annealing. The steels containing over 20 per cent. chromium may be depended upon to give long service at high temperatures even up to 2,000° F. provided the atmosphere is not highly reducing.

#### Austenitic Stainless Steels

Group 5 frequently referred to as austenitic stainless steels includes those that contain both chromium and nickel. The widely known 18 chromium—8 nickel steel is a member of this group. This steel is the most suitable for welding and has the widest range of usefulness for resistance to corrosion by liquids and to gases up to about 1,600° to 1,700° F. The chromium gives the metal resistance to oxidation. There are instances in which the austenitic chromium-nickel steel may contain as high as 0.20 per cent. carbon, but if the steels are to be welded 0.08 per cent. maximum is frequently specified and even less than this amount of carbon is often desired in welding rods and electrodes. Neither the weld metal nor the metal adjacent to the weld is hardened or embrittled by the welding operation unless the welds are cooled very slowly. Usually the weld will have less strength than the base metal, but the yield point of the weld will be slightly higher and the weld metal will be satisfactory in ductility and toughness in the "as welded" condition. The deterioration in corrosion resistance, which may sometimes occur, has been eliminated by the use of columbium, which will be discussed later.

As compared with ordinary steel, this "18-8" metal has a much higher coefficient of expansion associated with lower thermal conductivity. Because of these properties the welding, especially when applied to thin material, will cause serious warping unless provision is made to prevent this action. Clamps, copper chill plates, and jigs are used separately or in combination to hold the plates in line until the weld has cooled. Other advantages given by these appliances are greater ease and speed in welding, less absorption

of heat in the parts welded and more rapid chilling. Quick cooling is desired because the corrosion-resisting properties of the 18 chromium—8 nickel steels are adversely affected by heating to temperatures in the range, 800° to 1,400° F. These temperatures are reached in the base metal a short distance from the weld, and the shorter the time they are maintained the less the damage to the corrosion resistance of the material.

The 18 chromium—8 nickel steels that contain as much as 0.12 per cent. carbon have good corrosion-resisting properties for many uses, but if severe corrosion conditions are involved, the metal, if possible, should be reheated after welding for a short time to a temperature of at least 1,800° F. and cooled rapidly. The corrosion-resisting properties are much improved by reducing the carbon content to less than 0.12 per cent. The 18 chromium—8 nickel type of steel has been welded and used for a good many years. In most cases these steels have given excellent service.

#### Intergranular Corrosion

The type of attack that has sometimes occurred in and adjacent to the welds has become generally known as intergranular corrosion. Considerable effort has been put forth to eliminate this difficulty in welding structures and it is pleasing to report that a practical means of preventing this type of corrosion has resulted. By the addition of sufficient titanium and maintenance of low carbon content the difficulty with intergranular corrosion in the base metal is substantially eliminated. However, a second problem is involved; in welding, practically all the titanium is eliminated in passing from the rod to the weld. If one weld crosses another, or if the end of a welded seam comes in contact with the beginning, as in circular welds, the metal of the weld made previously contains no titanium, and hence is again subject to the intergranular corrosion produced by reheating.

It appears that a happy solution has been found to this second problem by the use of columbium instead of titanium. Columbium is lost only to a moderate extent in passing through the arc, and the loss is still a good deal smaller in the oxy-acetylene melting of the metal from the welding rod. This element is favourable because it does not produce an infusible oxide to interfere with the welding. A great variety of tests that have been carried out under the most severe conditions of corrosion indicate that with columbium-treated 18 chromium—8 nickel base metal and welding rods of the same composition the welds obtained will be free from intergranular corrosion. There is no question of the great improvement imparted to welds in these steels by columbium and experience justifies the use of this element, if the conditions of corrosion to be encountered are severe and especially if higher than ordinary room temperatures are involved in the service. With base metal and weld metal not susceptible to damage by reheating in the range of 800° to 1,400° F., vessels constructed by welding will safely withstand severe corrosive conditions without danger of failure due to local attack.

#### Development of Art of Welding

Group 6 stainless steels containing various combinations of nickel and chromium cover so wide a range and are employed for such varied uses that no general recommendations for their welding appears to be justified. It is recommended that for each specific application the manufacturer of the material be consulted for advice about its welding.

Group 7 covers the various castings that may contain as high as 28 to 30 per cent. chromium with or without additions of nickel. Usually the carbon content is high, ranging from 0.50 to over 2 per cent. The welding rods preferably should be of the same composition as the casting that is welded. In the plain chromium steel castings it is frequently necessary to preheat prior to welding while the majority of the castings of the chromium-nickel steels can be welded without this precaution.

In the course of the development of the art of welding in

general the application of the process was systematised and the system was given the name "procedure control." This "control" sets up a definite procedure that includes all the essential factors needed to insure successful welds. A parallel arrangement could be made of factors that are observed to aid good supervision in other types of construction. It has been found over a period of years that the intelligent following of this procedure control insures a satisfactory outcome to any welding project. The rules for welding, which have been set up by important regulatory bodies, and many specifications of materials and requirements in their welding, are based on this procedure control and it has been the greatest contribution to the wide acceptance of important structures fabricated by welding.

Procedure control has been outlined as follows: (a) Check of welders' ability, (b) selection and inspection of material, (c) design and layout of welded joints, (d) preparation for welding, (e) organisation and welding technique, (f) inspection and testing. Strict adherence to this procedure control leads to high quality and safety in welded products. Each

one of the items listed is important and should be observed in the welding of the chromium steels. The inspection applied to welds, especially pressure vessel welds, has been responsible for two new methods of testing that have been of great value, namely, X-ray examination and the "free bend" method of testing for ductility.

Stainless steels are used because they are the most practical and economical materials for resisting corrosion. However, this property is not the only reason for using the high chromium steels since their strength and toughness and other good qualities are also highly desirable. The use of these quality steels is justified because throughout their period of service the original strength will not deteriorate by the ravages of rust and chemical attack. Merely to use a stainless steel, however, is not sufficient. There is a correct stainless steel and welding procedure for a given condition of service, and care given to insuring a correct choice will be well repaid. The manufacturers of the steels and of welding supplies are in a position to give valuable assistance in this respect.

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## Protective Finishes on Zinc Means for Increasing Industrial Uses

THE application of zinc is widening day by day, due to the fundamental advantage which it holds as being the cheapest non-ferrous metal upon the market, said Dr. P. S. Lewis in a paper on "Protective Finishes for Zinc," read before the Electrodepositors' Technical Society, at Birmingham, on February 4. Zinc is also resistant to normal atmospheric corrosion, is easily fabricated and takes a high finish. The zinc-base die-casting alloys with their relative cheapness and high castability are peculiarly suited to modern mass-production methods, and their use is rapidly expanding. The corrosion coat of basic zinc carbonate which forms on zinc, and acts as a defensive sheath to the metal below, is unsightly, however, and it is to cover its aesthetic deficiencies that some form of artificial finish is desired.

Much has been published on the subject of electro-plating on zinc, and this can now be regarded as an established process, said Dr. Lewis. Plated coats of the usual metals, nickel, chromium, copper and silver, can be applied to zinc without difficulty provided that the usual standards of cleaning and degreasing are rigidly maintained. As on any metal surface, the application on zinc of a paint film, which will adhere satisfactorily, is not a simple operation. The thermal coefficient of expansion of all metals is high in relation to that of the paint films. The smooth, non-absorbent, metallic surface gives but little opportunity for that keying into pores which is necessary to fix and maintain the paint skin securely upon the surface. On most freshly fabricated metal surfaces, films of grease exist, which must be removed before adhesion can be assured. A factor of especial importance with zinc is its tendency, due to its chemical activity, to react with the acids of the dried paint film.

### Obtaining Prolonged Adhesion

In the case of zinc, these factors can be overcome by the adoption of some kind of pre-treatment, and this is advisable if prolonged adhesion is desired. The methods of pre-treatment available include natural weathering, sand-blasting, and also treatment with various solutions which tend to clean and etch the surface. Undoubtedly one of the best methods is the "Granodine" or "Lithoform" treatment. This consists in applying by brushing, spraying, or dipping, a solution of the phosphoric acid type. The grey surface so produced gives a high degree of initial adherence to paints and, being inert, remains permanently stable towards the dried film.

Enamel, lacquer, and varnish finishes on zinc are finding increasing application, particularly on die-casting alloys, and

a wide variety of finishes of these types, and also of Japans, is available. The same factors which militate against prolonged adherence of paint films on zinc hold in the case of these finishes, and some kind of pre-treatment is recommended. As in the case of painting, the "Granodine" or "Lithoform" treatment gives admirable results. A point of considerable importance when baked finishes are applied on die-cast alloys, is the fact that alloys containing only slight amounts of impurities, such as lead or tin, are susceptible to comparatively rapid intergranular corrosion in the presence of steam. This causes weakness and distortion. If alloys are made up with zinc of 99.99 per cent. purity, which is now commercially available, this tendency is no longer present, and such alloys can be safely stoved at temperatures ranging from 300° to 350° F. Since these alloys are so remarkably sensitive to very slight increase in impurity content, from the point of view of distortion in the stoving operation, the use of high grade zinc in this connection should be insisted upon.

### Coating by Chemical Methods

Chemical methods of coating zinc include chemical colouring, which is effected by dipping thoroughly cleaned articles in solution containing usually a copper salt; recipes for such solutions are many and varied. Such coatings are necessarily very thin and cannot be recommended for outdoor exposure. A chemical method which has had a wide application in the United States is the dichromate dip. Articles are treated by immersion for a few seconds in an acid dichromate solution. By this treatment, a coating of zinc chromate is formed which is unaffected by oxidising agents, and resists corrosion for a considerable time.

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TIN statistics in detail up to the end of 1935 have been published in the February issue of the Hague Statistical Bulletin of the International Tin Research and Development Council. Comparing the 1935 figures with those of the previous year, world apparent consumption increased by more than 20 per cent. from 117,681 tons to 141,524 tons. There was a very close agreement between the amount of tin produced in 1935 (139,053 tons) and the quantity used in manufacture (139,000 tons, approximately). The United States of America used 44 per cent. of the world's tin in 1935, compared with 37 per cent. in 1934. World production of tin in 1935 increased by more than 30,000 tons over the 1934 output.

## Recent Metallurgical Patents

### Alloys for Bearings

AN alloy for bearings consists of at least 95 per cent. of cadmium and 0.05-5 per cent. of silver, preferably with the addition of 0.25-1 per cent. of a hardening metal, particularly copper or nickel or both. Up to 0.25 per cent. of zinc may be present. A bonding alloy for uniting the above alloy to a steel base may consist of 80-95 per cent. of cadmium and 5-20 per cent. of zinc. (See Specification 436,633, of General Motors Corporation.)

### Magnetic Materials

IRON-NICKEL alloys in the form of a sheet wire or band which has been subjected to repeated rolling or stretching will intermediate heatings at 900-1,000° C. are, after the last heating, stretched or rolled so as to reduce the cross-section by 20-40 per cent. and then heated at a temperature up to 500 or 600° C. for about 1-3 hours. The last heating may take place in air or hydrogen and the preferred temperature is 400° C. (See Specification 436,931, of Naamlooze Vennootschap Philips' Gloeilampenfabrieken.)

### Deoxidising Metals

METALS are deoxidised by treating them with a very fluid oxide-extracting slag containing not less than 5 per cent. and not more than 90 per cent. of titanium oxide and acid, neutral or basic oxides usually contained in metallurgical slags and in such relative proportions that the slag has an acid character and is capable of extracting the oxides from the metal treated. In an example, a slag contains 35 per cent. of titanium oxide, 25 of silica, 30 of alumina, 5 of lime and 5 of manganese oxide. (See Specification 436,450, of Soc. D'Electro-Chimie, D'Electro-Metallurgie, et des Acieries Electriques D'Ugine.)

### Recovering Precious Metals

PLATINUM metals are separated from mattes, such as nickel-copper mattes, by the addition of a solid non-metallic segregating agent to the molten matte, allowing the matte to form two layers and separating the two layers before, during or after cooling of the matte. The segregating agent may be silicon, phosphorus or boron, or alloys or compounds thereof, and such agent may be incorporated with or used in conjunction with a diluent or blending agent; for instance, ferro-silicon or phosphor-copper may be employed. The segregating agent is preferably added in a ladle as the matte is poured from a converter in which it is blown, the temperature of the matte being between 1,100 and 1,400° C. (See Specification 438,996, of Mond Nickel Co., Ltd.)

### Coating with Metals

IN the production of deposits of alkali and alkaline earth metals within sealed vessels for photo-electric cathodes, gettering and other purposes. A mixture of an oxide or carbonate of the metal and aluminium, the number of atoms of aluminium being equal to or rather larger than the number of oxygen atoms or CO<sub>2</sub> radicals, is heated in hydrogen at atmospheric pressure to about 1,000° C. It is stated that the resulting product is stable in air and that the electropositive metal can be liberated by heat. This product is introduced into the vessel in pellets or otherwise and heated in vacuo to 1,000° C., or over. In preparing the material, oxides of barium, strontium, calcium and lithium are preferable and carbonate of sodium. The process is not practically possible for caesium and barely so for potassium. When oxides are employed they may be heated in vacuo instead of in hydrogen, and at a temperature of only 700° C., gas being continually pumped out. In producing a photo-electric cathode the material may be enclosed in a nickel tube, which may be heated by a resistant coil and directs the metal to the required spot. (See Specification 436,527, of M-O Valve Co., Ltd., and M. Benjamin.)

## Foundry Science

### Progress of the British Foundry School

THE British Foundry School, which offers a training of one year's duration, of the most advanced character, in foundry science and practice, made an excellent beginning in October, 1935, and thirteen students are taking the course for the first session, now in its second term. In addition to the lectures and laboratory work, supervised by a permanent lecturer-in-chief, Mr. J. Bamford, B.Sc., special courses are given by members of the staff of the Birmingham Central Technical College in which the school is housed. Furthermore, over fifty lectures were given during the first term by nationally-known specialists in various aspects of foundry work. Each week a foundry visit is made, and during the session it is hoped to arrange for a three-day visit to another foundry centre.

Students, in the main, have been nominated by their employers and the school authorities are now prepared to receive the names of prospective students for the next session, beginning in September, 1936. A prospectus may be obtained from the School, or from Mr. J. G. Pearce, 21 St. Paul's Square, Birmingham, 3.

## The Institute of Metals

### Annual General Meeting

THE twenty-eighth annual meeting of the Institute of Metals will be held in London on Wednesday and Thursday, March 11 and 12, at the Institution of Mechanical Engineers, when the new president, Mr. W. R. Barclay, O.B.E., will be inducted into the chair. After delivery of the presidential address papers will be read and discussed during the day, and in the evening the Institute's annual dinner will be held at the Trocadero Restaurant. In the morning of March 12 further papers will be presented for discussion, and in the afternoon visits will be paid to Broadcasting House; the Royal Observatory, Greenwich; the Fuel Research Station, Greenwich; and to Fleet Street newspaper offices.

In the evening of Tuesday, March 10, there will be a discussion on "Metallic Wear." This will be opened by Dr. H. W. Brownsdon, with a paper which reviews some of the major factors involved in metallic wear and indicates a method by which they can be quantitatively assessed. The problems involved interest not only engineers, but also chemists, physicists and metallurgists. The special aspect of the subject appealing to those workers will be dealt with by contributors to the discussion.

As the subject of metallic wear is one of wide interest, members of other institutions—including the Institution of Mechanical Engineers, Institution of Naval Architects, Institution of Automobile Engineers, Iron and Steel Institute and Royal Aeronautical Society—have been invited to attend the meeting and to take part in the discussion. Cards of invitation may be obtained from Mr. G. Shaw Scott, Secretary of the Institute of Metals, 36 Victoria Street, London, S.W.1.

### Heat Treatment of Steel

ALMOST any kind of factory uses heat treatment furnaces of some kind, either for production processes or in the tool room. As standards of production rise, so the necessity for accurately controlled heat treatment becomes more important. "Heat Treatment of Steel," No. 6 of the Industrial Uses of Gas Series published by the British Commercial Gas Association, contains a remarkably concise explanation of the theory of the various processes of heat treatment. It explains the real significance of the terms used and states the requirements of each class of work. Another section deals with the design of gas furnaces and indicates the circumstances under which different types should be used, and a third section describes some twenty odd representative modern installations. The book is illustrated with photographs of the plant described.



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# Metallurgical Section

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April 4, 1936

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## Research on Tin and Tinplate

THE corrosion resisting properties of tin are the reason for its use as a coating metal over steel in the form of tinplate. In several of its uses tinplate is exposed to corrosive conditions and in some of them the tin itself is attacked. A review by Dr. T. P. Hoar of the mechanism of the corrosion of tinplate under conditions such as those obtaining in the cans used for packing foodstuffs has just been published by the International Tin Research and Development Council, as Technical Publication Series A, No. 30.

The corrosion of tin and of steel, separately and together, is considered. Two main types of attack occur with tin, depending on whether the protective oxide film formed by exposure to the air is completely removed or merely partially penetrated. The attack on steel by acid liquids depends very much on the presence of traces of inhibitors such as proteins and tin ions and accelerators such as sulphide, and also, whether or not air is present. In tinplate, tin and steel form an electrolytic couple which in recent years has been closely investigated, and it has been established that the tin or the steel can be cathode in the tin-steel couple under suitable conditions. If the tin dissolved forms stable complexes with the anions of the attacking medium, tin will normally become anodic to the steel.

As regards corrosion, steel has peculiarities which have only been discovered recently and these have also to be taken into account. Another factor is the layer of tin-iron compound always present between the steel and its tin coating and is the subject of investigations which are still proceeding. Several factors which tend to reduce corrosion in sealed food cans and the use of lacquers for the same purpose are dealt with. Among the practical remedies for tinplate corrosion are coating with lacquer or with electro-deposited tin and improvement of the steel base.

### Hot-Tinning of Copper

FURTHER researches by the International Tin Research and Development Council on the hot-tinning of copper are contained in two new Technical Publications, reprinting papers read before the Institute of Metals.

In Series A, No. 32, Dr. W. D. Jones' investigations on the "Influence of Surface Inclusions on the Porosity of Hot-Tinned Coatings on Copper" deal with one of the most important causes of porosity. Preliminary tests indicated that the production of porous, irregular tin coatings on copper during hot-tinning is associated with the presence of inclusions of cuprous oxide in the copper base, and that relatively non-porous, smooth coatings are produced in the absence of such inclusions. The presence of cuprous oxide inclusions can be readily detected by amalgamation of the copper surface at room temperature by the use of acid mercuric chloride.

Copper containing oxide inclusions can be made to

give non-porous smooth coatings by certain special pre-treatments which reduce the cuprous oxide to metal. Thus, the copper may be simply immersed for some minutes in cold hypophosphoric acid (2 to 50 per cent.) or treated cathodically in dilute caustic soda solution, the latter process being the more satisfactory. Smooth tin coatings are readily obtained on oxygen-free copper in the absence of any special pre-treatment, and this material is recommended as the most suitable for hot-tinning.

In series A, No. 33, Mr. E. J. Daniels describes experiments of the "Hot-Tinning of Copper: the Attack on the Base Metal and its Effects." Here the author points out that examination of cross sections of tinned and soldered coatings on copper shows that there is always  $\text{Cu}_3\text{Sn}$  in contact with the copper and a layer of  $\text{Cu}_6\text{Sn}_5$  over it. This duplex layer tends to detach in fragments as it is formed, leading to contamination of the tin in the bath and the coating. The effect of this copper contamination on the irregular coatings typical of those on copper containing cuprous oxide inclusions, is beneficial up to about 1 per cent., due, it is thought, to the compound particles anchoring the liquid tin on the surface of the copper. This is in accordance with the fact that deliberate addition of copper to fresh tinning baths is common works practice. Excess of copper leads to rough coatings.

### Solubility of Antimony in Tin

DEALING with "The Constitution of the Tin-Rich Antimony-Tin Alloys," Professor Hanson and Mr. Pell-Walpole (Technical Publication Series A, No. 31) state that a range of alloys containing from 2 to 14 per cent. antimony were prepared by melting tin under charcoal and adding the antimony in the form of a temper alloy consisting of 50 per cent. each of pure antimony and tin. Thermal analysis, microscopical analysis and measurement of electrical resistivity were used to determine the constitution of the alloys.

Alloys were examined after the following treatments: (1) chill-cast, (2) annealed for four weeks at  $190^\circ\text{C}$ ., and cooled in the furnace, (3) quenched from  $190^\circ\text{C}$ ., (4) quenched from  $190^\circ\text{C}$ ., but then tempered for one hour at  $100^\circ\text{C}$ ., (5) quenched at temperatures between  $190^\circ\text{C}$  and  $245^\circ\text{C}$ . The solubility of antimony in tin is shown to decrease from 10.5 per cent. at  $246^\circ\text{C}$ . to 4 per cent. at  $190^\circ\text{C}$ . and to 3 to 5 per cent. at  $100^\circ\text{C}$ . The form of the solubility curves suggests that the mechanical properties of some of the tin-rich bearing metals might be sensitive to heat-treatment and further researches are proceeding in this direction.

Copies of all the above publications may be obtained free of charge from the International Tin Research and Development Council, Manfield House, 378 Strand, London, W.C.2.



## Recent Advances in Metallurgy

### Professor D. Hanson Addresses the Midland Metallurgical Societies

**I**N an address delivered to the Midland Metallurgical Societies at Birmingham on March 17, Professor D. Hanson, of the Metallurgical Department, University of Birmingham, said it was impossible to cover the whole of the developments in modern metallurgy, so he was going to take a few aspects of physical metallurgy and say something about the lines of thought in these directions. Some of the investigations to which he would refer were a little difficult and rather involved, but he would try to simplify it as much as he could. They would see that some of the developments in physical metallurgy had also involved some difficult investigations in physics. The theory of to-day became the practice of tomorrow, and some of these investigations would lead to developments about which they knew absolutely nothing at the present time.

#### Equilibrium Diagrams

Before proceeding he would for a moment take his listeners back before the dawn of metallography, when alloys were considered to be nothing but mixtures. Metallurgists knew then that if one added one metal to another one altered the properties, but they did not know why such alterations took place. When metallurgists examined metals under the microscope for the first time, and discovered that they had internal structures, one of the greatest developments in metallurgy had taken place. Many anomalies became understandable. It was soon possible to understand that these alloys were composed of different phases, which in turn led to a better knowledge of the foundation of alloys than anyone had had before. Improved methods of investigation were discovered, until to-day one had a large number of diagrams which told of what our metals consisted.

Some people still sneered at equilibrium diagrams, but he hoped that he had not to defend them before those who were present that evening. These diagrams were the only basis one had in order to know what happened when metals underwent heat treatment, and, whenever the microscope was used, one was also using these diagrams, because it was a result of these that so much was known and understood to-day about the microstructure of metals and alloys. A lot of work was now being done in this country and elsewhere on systems which consisted of three metals. Much greater accuracy was being obtained and attention was also being given to change of phase in the solid state.

#### Limitations of the Microscope

Continuing, Professor Hanson said he would also take this opportunity of stating that in his opinion work of that kind was essential if they were to have a sound basis for their metallurgy. The developments and extension of heat-treated non-ferrous alloys which may be made amenable to age-hardening could only be explained and perfected by investigations into their construction. Ternary alloys such as the nickel-silicon-copper and nickel-tin-copper alloys were becoming increasingly important, and it was his belief that many important developments were to be expected in the immediate future in this direction. The microscope had obvious limitations—it could not tell them what the substances in their alloys actually were, while the chemical analysis of these alloys told them even less, and until quite recently all they could tell from the microscope was whether they were dealing with solid solutions or what were termed compounds, without a knowledge of either.

The developments which had given knowledge of the different phases were most spectacular. It was a subject which was developing at the present time, and formed part of the general study of the nature of the solid state of matter about which they knew actually very little indeed. They saw

things through the microscope by the use of light of a certain wave length, and anything which was of the wave length of light or of smaller wave length, the microscope took no notice of, and in order to find out about those things which were smaller than the wave length of light something else had to be used. They used X-rays, the use of which was introduced by Laue. He realised that the atoms of a metal crystal were arranged regularly in space, and the distance between the atoms was about the length of the waves of X-rays.

#### X-Ray Investigations

By taking X-rays and allowing them to fall on metal, and observing the manner in which these rays were scattered, it was possible to see where the atoms were inside the metal. That told a lot about the metals that no one knew before. It was found that the atoms were arranged according to space lattices—that the arrangements of these lattices differed from metal to metal, but that there were a strictly limited number of these lattice types. Most of the ductile metals belonged to one class, metals like zinc and manganese to another, iron, tungsten and molybdenum to another, while tin, bismuth and antimony belonged to yet other types of structure, and these four or five types of structure covered the whole of all the types of metals.

It was therefore possible, continued Professor Hanson, to define the metals by their atomic structure, but they knew that alloys consisted of solid solutions, so the next problem which called for solution was—what were solid solutions? If one took a certain lattice and inserted other atoms into it, such as with aluminium and copper, how would one expect the aluminium atoms to arrange themselves within the copper atoms? He did not think anyone could have told that without investigation. X-rays had told them the answer to most of the questions involved. Let them consider what happened to the lattice pattern when one element dissolved in another. Copper had a unit cube of 3.61 Angstrom units. The addition of aluminium expanded the lattice and made it bigger. The atoms actually moved further away from one another. Again in the system of gold-copper alloys, the gold crystal was contracted when copper was added to it, and the copper crystal was expanded.

In doing that where did the stranger atoms go to? Copper atoms might take the place which ought to be occupied by gold atoms, or copper atoms might find positions in between the gold atoms. X-ray analysis would tell them that. If they measured the size of the unit cells and at the same time measured the density of the alloys, then knowing the number of atoms and knowing the spacing, they could calculate what the resulting density ought to be. In most metallic alloys the atoms went into solution by substitution for parent atoms. In any systems of alloys they had to deal with a variety of solutions, for instance, when zinc was added to copper one obtained solid solutions which formed the different classes of brasses. What were all these different phases? They used to think they were all compounds, and they tried to find formulas for them, but with little success. To a large extent they had now discovered what they were.

#### Complicated Cubic Structures

Copper was, of course, a face centred cube of 3.608 Angstrom units. As zinc was added the structure was expanded and altered as the zinc addition was increased. The beta phase was centre cubic with a parameter of 2.946 Angstrom units, while the gamma phase was a more complicated cubic structure containing 52 atoms in the unit cube. They had therefore discovered that the different phases were in effect different types of structure. The amazing thing was that although

there were all these different phases in metals, the number of lattice types was very small. In that, they differed from ordinary chemical compounds in which the type of crystal was in effect a reflection of the molecule. The valencies of the different atoms determined the way in which they hung together, and there were a number of types of crystal in which similar atoms always occupied similar positions. In alloys, they differed from ordinary compounds in that the valency bond was much less. Compounds were frequently non-stable and frequently dissociated before they melted.

Professor Hanson continued by saying that the next advance was due to discoveries between the different phases. It was noticed that the beta phase had very similar properties in many instances. They had less ductility than the alpha phase, whereas the gamma phase was brittle. It was noticed that the higher the valency the lower the change. A very interesting generalisation was that the intermediate phases conformed to a few types and difference in type of phase was due to the ratio of free electrons to atoms. Broadly, the rule was that for each lattice type there was a ratio of free electrons to atoms. There were so many that conformed to this rule that there was every reason to believe that it had a sound foundation in fact.

### Lattice Types and Atoms

He had spoken of the gamma brittle phase and had said the lattice structure was not simple. The gamma structure was a cubic one with 52 atoms in the unit cube. The pattern of the atoms was the same for copper-zinc, silver-zinc, gold-zinc and copper-cadmium alloys, but if one examined them very closely they found the distribution of atoms in the pattern varied from system to system. When one had isomorphous compounds similar atoms occupied similar positions, but in alloys of the character mentioned, similar atoms did not occupy similar positions. This was the next important discovery with regard to phases, not only was there a limited number of lattice types, but it was beginning to appear that the nature of the types was independent of the nature of the atoms.

The technique of this was not too difficult for the younger man to understand and grasp, but the fuller understanding of the nature of crystals would probably involve investigations into the distributions of the electrons, and work was proceeding in that direction. Still more than he had yet mentioned had been learned about crystals by means of X-rays. He had referred to the solid solution as a form of crystal in which the atoms occupied positions on the space lattice, and he had referred to types of crystal in which the only thing that mattered was the nature of the lattice, and the position of the atoms was unimportant.

### The Working of Metals

In many types of solid solution, the theory was that the atoms would be distributed in a more or less random manner. That was the general condition so far as they knew it in solid solutions, but in some alloys one could get the atoms in a solid solution arranged in a state of disorder or an orderly arrangement according to the temperature of the alloy and its heat treatment. The orderly condition appeared at the lower temperature and was one of lower energy. As the temperature was raised, the thermal oscillations of the atoms tended to make them move about, and the transition became more rapid, so that one might have in the same phase an orderly or a disorderly arrangement. Examples were known in the gold-copper and iron-aluminium alloys and no doubt they would find a lot more.

The working of metals was a thing which they all met with in the course of practice, and it would be interesting to see what happened to crystals when they deformed. Imagine they had an arrangement of atoms built up into a certain structure. What happened when the structure was deformed? One thing they knew about it was that when it was deformed one did not appreciably alter the distances between the atoms. The crystal did not distort uniformly, but split up into blocks and distortion took place by means of block movements and took place

along the slip bands. The microscope alone could never tell in what direction this movement would take place, and no one knew until fairly recently what did happen when metal was deformed.

Metals were made up of crystals which were very small, which made it very difficult to analyse what was happening in each of the crystals. Some years ago, various methods were discovered by means of which they could obtain single crystals inches long, big enough to pull into a test piece, and study as an individual crystal. With these crystals they had been able to study what happened when a metal was deformed. Taylor and Elan took aluminium crystals in the form of a rectangular rod. Lines were ruled on them and they were put into a testing machine, and by measuring the changes which took place between the lines they were able to come to certain conclusions. They decided that the distortion must take place by gliding movements over the planes within the crystals, and they were able to find which planes were involved. Not only did the shearing movement take place on the octahedral planes, but they took place in a certain direction.

Dr. Gough, Mr. Wright and Dr. Hanson had also done work on aluminium. They polished a crystal all over, put it into a machine and subjected it to alternating torsion stresses, and by measuring the position of the slip bands they were enabled to determine that it was the octahedral planes which were involved, and they were able to ascertain the manner in which slip took place, and these results agreed with those arrived at by Taylor and Elan.

### Distortion and Hardening

To sum it all up, said Dr. Hanson, they found that slip took place on the planes within the crystal, and these were the octahedral planes. In the face-centred cubic crystal there were twelve directions in which the crystal could slip, and in no other way. Distortion had been determined by the same means in other types of crystal, for instance, in any one zinc crystal there were only three ways in which it could slip. The iron crystal was rather different and behaved differently. The movement there took place in the direction of certain rows of atoms and tin was the same. These rows were those in which the atoms were the nearest together.

Another question which followed was: When this deformation took place, why did the metal become hardened? For moderate distortion one could ascertain nothing by means of X-rays, but when distortion was getting near to the point of fracture one could see something of the changes, which they had found to be akin to rumplings of the lattice planes. The planes became wavy, as if they were displaced and the direction of the waves was related to the direction of the shearing movement. When these waves reached a certain point, minute cracks began to form and it seemed that once one began to get this rumpling, the crystal movements were less easy and if points of fracture were commenced it was easy to understand how a big fissure would develop, and finally there would come failure. Failure was a gradual spread from many centres until they grew bigger and bigger.

### True and Theoretical Strength

There were a great many problems to face before they knew why metals had the strength which they possessed. Physicists said metals were woefully weak, that the strength of metals as they knew it was only about one thousandth of what the physicists said calculations showed. There were many lines of argument in that direction. The fact that metals as they knew them were not so strong was probably to be sought in the variations from the ideal structure of the perfect metal crystal. One school explained the weakness of crystals as due to the presence of internal flaws. Another view was that the surface flaws acted as notches and prevented the metal from being strong. Yet another authority thought the weakness was due to a mosaic in the crystal.

Professor Taylor, at Cambridge, had elaborated a theory of the deformation of the crystal, which promised to throw a lot

of light on the strength of materials generally. If one took a crystal of metal and plotted a stress-strain curve, this curve was found to be parabolic. Taylor was led to seek some modification of the views of distortion. Previously this had been viewed as the movement of one block over another. On the theory of the lattice however, it was difficult to realise how this could take place, as the strains involved would be enormous. Taylor supposed that the slip did not consist of simultaneous movement over the whole slip plane—it might happen by a dislocation which could travel across the lines of the atoms. He followed this up by mathematical analysis and arrived at very interesting results. One of the consequences of his argument was the postulation of the existence of a mosaic structure

in crystals, and this formed an essential part of the theory. He was able to deduce the approximate size of the mosaic, which was approximately that arrived at previously by observation, and to give a quantitative theory of work-hardening.

In conclusion, Professor Hanson said the information he had tried to impart had been rather involved and abstruse and some of his audience might find it difficult to grasp. There was, however, less difficulty in it for the younger men, whose training was in line with the newer ideas. The study of metals by means of the microscope offered difficulties in its early stages, and the matters which he had outlined would, in the future, become part of the usual course of study in physical metallurgy.

## Electro-Plating with Rhodium Metal

### Reasonable Cost Within Certain Limits

A RECENT issue of "Technische Blätter," 1936 (No. 6), contains an informative article on electro-plating with rhodium. It is stated that the present German price of the metal is about 4.50 marks per gram, compared with a price of 3 to 3.50 marks per gram for platinum, and as a good and durable rhodium plating can be obtained on a square metre of surface from 1 gram of rhodium, the plating with this metal within certain limits is not too costly.

Rhodium is not attacked by acids, caustic alkalies, or salt solutions of any kind, and is entirely unaffected by atmospheric influences so that its colour and lustre are permanently maintained. In these properties, shared in some degree by chromium, rhodium possesses one property which is not shared in the same degree by chromium, that of a relatively high light reflectivity. In this respect rhodium is superior to chromium, nickel or platinum, not only in reflecting more light but also in the uniformity of the reflection over the visible range of waves; chromium, for example, in the range of the short wave lengths, gives a bluish reflection.

#### An Untarnishable Surface

Rhodium is a very bright white silver-like metal and with its untarnishable property it is especially suited for the plating of silver objects, which in the unprotected condition quickly tarnish when sulphur is present in the air. This protection cannot be reached by alloying silver with rhodium, but only by giving it a surface of untarnishable metal like rhodium. When plated with rhodium, the original silver colour is unchanged. In addition to give permanence of colour, the rhodium plating of silver increases the mechanical resistance of the surface due to the superior hardness of rhodium as compared with silver. Rhodium also shows good resistance to elevated temperatures, and this explains the recent employment of rhodium plating for the cinema industry and for tableware. Rhodium plating is also employed for relatively cheap jewellery; such articles, with a very short time in the plating bath, obtain a brilliant silver-white colour which does not change. In other directions rhodium plating is being used for mirror surfaces; here the high light reflectivity and stability of its high polish makes it specially suitable when mirrors are required for special purposes, as in the cinema industry. Rhodium electro-plate is also suitable for chemical laboratory appliances, for the plating of metal cocks and other parts exposed to a corroding atmosphere, and the manufacture of surgical and dental instruments. In addition, the electrical manufacturing industry is using rhodium plating for contacts, because it is an effective protection against corrosion.

The plating operation is considerably more simple than in

plating with chromium, and is comparable in this respect with gold or silver plating. In contrast to chromium plating, rhodium plating is carried out at room temperatures. As the metal deposits with a cathode output of about 90 per cent., the hydrogen development is small, and the forming of noxious or poisonous vapours is not to be feared. The depositing baths are supplied by the trade in concentrated form, and merely require dilution with seven equal volumes of distilled water in order to be ready for use. The prepared bath contains 2.5 grams of rhodium per litre, and can be used almost to the point of the exhaustion of the metal. For containing the bath, vessels of porcelain, earthenware or thick glass are suitable. Platinum sheet of about 0.04 mm. thickness suspended in the bath serves as anode. The temperature of the bath is 20-25° C. and the bath tension at the beginning 2.0-2.5 volts, which increases to 3-4 volts towards the end; this corresponds to a current density of 0.3-0.5 amp. per square decimetre. In the fresh condition, the bath has a deep orange colour which gradually becomes lighter as the bath becomes poorer in rhodium; this is a useful indication of the strength of the bath, showing when renewal of the metal content is necessary. Objects to be plated become white in a few seconds after being suspended in the bath; the high strewing property of the bath ensures that all parts of the object including hollow parts and the back side become uniformly plated and in this respect this is superior to chromium baths. Yellow brass pieces are coated white in 1½ minutes, and in 3 to 6 minutes have received a good adhesive plating.

#### Preliminary Cleaning Operations

In three minutes 0.005 gram of rhodium is deposited on a square decimetre of surface and in six minutes double that quantity. Objects which are required to withstand hard use receive 6 to 10 minutes deposition, but scaling off of the deposit is not to be feared after 15 minutes in the bath. An important requisite in rhodium plating is absolute cleanliness of the surface to be plated; a solution recommended for this purpose is one containing caustic soda, water glass, and sal ammoniac. The article is placed in a bath and serves as a cathode in the above solution, and is electrolytically cleaned. The bath tension is from 4 to 8 volts and the current density 3 to 5 amp. per square decimetre. The article is then washed in weakly acidified water and transferred directly to the plating bath.

The surface properties of the object to be plated are not changed in the plating operation; highly polished surfaces remain highly polished, matted or scratched surfaces are unchanged.



# The International Nickel Co. of Canada

## A Record Year for Sales and Profits

**T**HE progressive improvement in the business of The International Nickel Company of Canada, Ltd., which started in May, 1932, continued throughout 1935, states the annual report of the company, recently published. Total sales of nickel were in excess of those recorded during 1929, which formerly was the peak year in the history of the nickel industry, and consumption was well diversified geographically and industrially. New sales records were achieved, not alone for nickel but for copper and the platinum metals as well.

During the year operations at mines and plants were conducted without interruption and output was increased in order to meet the growing demand for the company's products. As a result of these activities unemployment was reduced in the Sudbury district as well as in the town of Port Colborne where the Canadian nickel refinery is located.

A net profit of \$26,086,527 was realised after all charges including provision for taxes, depreciation, mine depletion and other purposes. After payment of preferred dividends of \$1,933,898 there remained \$24,152,628 or \$1.65 per share of common stock. Cash on hand of \$30,473,311 indicates a strong financial position which is now more than ever necessary to assure at all times adequate production facilities and a continuation of aggressive market development to meet the exigencies of expanding business.

### Sales Statistics

Sales of nickel in all forms, including nickel in alloys, amounted to 129,850,207 lb., comparable with 91,459,554 lb. in 1934, an increase of 42 per cent. Sales of nickel in products of the Port Colborne and Clydach refineries amounted to 105,620,318 lb., comparable with 73,964,621 lb. in 1934, an increase of 43 per cent.; nickel products of the Copper Cliff smelter amounted to 4,085,570 lb., comparable with 1,357,008 lb.; nickel in products of the rolling mills at Birmingham, Glasgow and Huntington, and of the foundry at Bayonne, totalled 20,144,319 lb., comparable with 16,137,925 lb., an increase of 25 per cent. Sales of "Monel metal," made direct from Creighton ore, totalled 13,411,624 lb., comparable with 10,763,821 lb. in 1934, an increase of 25 per cent.; sales of pure rolled nickel were 9,339,595 lb., comparable with 7,469,914 lb., an increase of 25 per cent.; and sales of "Inconel" increased from 428,605 lb. to 609,632 lb. or 42 per cent.

Sales of copper increased from 194,870,682 lb. in 1934 to 233,009,392 lb., or 20 per cent. Gold sales were 69,944 oz., comparable with 74,375 oz. in 1934; silver, 3,160,222 oz., comparable with 1,006,808 oz.; platinum metals, 128,874 oz., comparable with 124,424 oz. Sales of selenium were 72,616 lb., comparable with 73,516 lb. in 1934; tellurium increased from 1,110 lb. to 9,987 lb.

### Improved Smelting Conditions

During 1935 a total of 3,382,409 tons of ore was mined and shipped to the smelters at Copper Cliff and Coniston; the Frood mine furnished 2,875,599 tons, the Creighton mine 506,810 tons. By replacing mild steel skips with lighter skips made from nickel steel the hoisting capacity at the Frood and Creighton mines has been increased approximately fifteen per cent.

The concentrator treated 2,584,666 tons of ore, the largest tonnage handled since this plant was built. Further improvements in metallurgy were effected and from the standpoint of efficiencies and recoveries results were the most gratifying thus far attained. Milling was increased to 8,000 tons per day and it is planned to expand capacity to 11,000 tons per day during the current year. Results have further shown the value of research experimentation and work of this character

will be intensified when the new research laboratory is completed. Savings have been realised by the use of nickel steel, "Ni-Hard" and "Monel metal" in concentrator equipment.

At the Copper Cliff smelter all of the reverberatory furnaces (five in number) and all twelve converters, were in use from February until the end of the year. Operating results were satisfactory in respect to tonnage of ore smelted, fuel consumption and slag losses. The Coniston smelter, with the exception of the month of July, ran continuously with four blast furnaces and five converters in operation, and plant practice was efficient as reflected in the higher percentage recovery of metal from ore smelted.

The company's hydro-electric power plants are in good condition and the capital expenditures thereon during the year were comparatively small. All of the plants are fully equipped and were operated throughout the year to the extent of the available water supply.

### Refineries Giving Maximum Output

Increased demand for nickel necessitated operating the electrolytic plant of Port Colborne nickel refinery at capacity for the first time since additional units were installed in 1929. The year began with six circuits in service, to which were added during the year the three reserve circuits, thus bringing the refinery to maximum output. There was produced 80,381,532 lb. of nickel in all forms. Continuous research and experimentation have resulted in many minor process improvements through which improved quality of product and lower costs have been attained.

At the Ontario copper refinery there was a substantial increase in the tonnage of blister copper treated, and plant output and copper shipments increased correspondingly. Refined copper production was 109,966 tons, comparable with 95,558 tons in 1934. Here a new selenium plant was completed and put into operation in March, 1935, thus enabling the company to produce a substantially larger quantity of this metal. In order to eliminate silver losses and to further increase recovery of selenium a Cottrell electrical precipitator was also installed and has shown satisfactory results. A plant to produce "single" and "double" nickel salts for the Canadian market was authorised in 1935 and is now completed and in operation.

### Production Costs

The output of nickel in the form of pellets at the Clydach nickel refinery, Wales (Mond Nickel Co., Ltd.), was 28,579,015 lb., comparable with 25,568,644 lb. in the previous year. In addition 2,504,902 lb. of metal were absorbed in the production of 12,136,255 lb. of nickel salts for which there is a steadily growing demand for nickel plating and in soap and edible oil manufacture. With the re-conditioning and re-modelling of another unit, shortly to be completed, this refinery will have an annual capacity of 42,000,000 lb. of metallic nickel which with a relatively small additional expenditure can be raised to 50,000,000 lb.

Costs show a reduction from previous years and with a larger production it is believed they may be further decreased. The small high-pressure carbonyl plant, referred to in the last report, has passed from the experimental to the production stage and is proving a valuable auxiliary to the refinery. The knowledge gained from research in connection with refinery problems and processes is proving of great value and this work is being proceeded with energetically. The established employees have had practically full time work, and in addition a considerable number of men were taken on temporarily for construction work.

At the Acton platinum metals refinery, London (Mond Nickel Co., Ltd.) efficiency was well maintained, as shown

by the low cost of production and by the high purity of the metals produced. The specious metals research and development department continued its investigations into the uses of platinum metals and their alloys; with that object in view contacts with the consuming trades were extended.

The progress of Henry Wiggin and Co., Ltd., a subsidiary of The Mond Nickel Co., Ltd., year by year since 1931, both in plant operations and sales, has been gratifying. The output of metallurgical and chemical products has more than doubled during that period. The year under review showed an increase of 11 per cent. over 1934. Rolled products from Wiggin Works, Birmingham, show a steady increase in metallic nickel consumed, this company now being the largest user of the metal in Great Britain. The sales of "Monel metal" continue to expand and now comprise nearly 30 per cent. of this company's total metal sales.

Capital expenditures of the International Nickel Company of Canada, Ltd., for 1935 amounted to \$3,206,642 comparable with \$2,395,257 for 1934. This expenditure included \$197,621 for the Ontario copper refinery, and \$584,512 for Port Colborne and Clydach nickel refineries.

During the summer of 1935, under the terms of the agreement (mentioned in the last report) between The Mond Nickel Co., Ltd., and the Government of Finland, exploratory work was started on the Petsamo concession. Permanent camps were established and a road was built from the state highway to the most promising prospecting areas. The concession was surveyed in conformity with the Finnish Ordnance Survey. Results obtained justify further exploration and the programme of work planned for the summer of 1936 embraces

diamond drilling, magnetic and electrical topographical surveying, road building, power investigation, and a study of transportation problems.

Estimated world deliveries of nickel in all forms from all sources during 1935 amounted to 160,000,000 lb., as compared with 122,000,000 lb. in 1934 and 136,000,000 lb. in 1929. During 1935 there was recorded the third successive annual increase in world consumption. Nickel prices remained substantially unchanged throughout the year. As in previous years the increased consumption during 1935 was well distributed among the various nickel-consuming countries and reflected the rates of industrial activity in these countries. The utilisation of nickel continued likewise to be well sustained in the different fields into which it enters, and each of these fields participated in the increased consumption as compared with the previous year. The automotive industry was the largest consumer.

The production of stainless steel required substantially more nickel in 1935, both in America and Europe. It is estimated that the 1935 production in the United States, of nickel-bearing stainless steel, so-called "18/8," increased about 40 per cent. over that of 1934. Well established in many fields of application stainless steel has acquired still further importance in chemical manufacture, in the oil and in the pulp and paper industries. The performance of stream-lined trains of stainless steel construction has focused public interest upon the possibilities of this material for light-weight corrosion-resistant structures, and further progress in this direction may be noted in the recent purchase of stainless steel passenger cars by the French State Railways.

## Some Recent Metallurgical Patents

### Annealing

IN a process of uniting metal bodies wherein stresses introduced therein are released by removing material, stresses may be introduced in a cylinder of soft iron by chilling from 680° C., in water, and in a steel ring by heating it to 650° C., and spraying with water on the outside. (See Specification 436,961, of Vereinigte Stahlwerke Akt.-Ges.)

### Treating Metallic Surfaces

OXIDE films are formed on aluminium and its alloys by treating the metal in alkaline baths containing chromates under super-atmospheric pressure and at a temperature above 100° C. The super-atmospheric pressure is obtained by controlling the release of the hydrogen from the container in which the reaction is carried out. Sodium chromate may be added to a bath containing an alkali such as sodium carbonate, potassium carbonate, ammonia, milk of lime or barium hydroxide. The bath may be heated to a temperature of, for example, 115-120° C. The treatment of tubes and of parts having narrow grooves or passages is referred to. (See Specification 439,404, of Peintal Soc. Anon.)

### Iron-Chromium Alloys

IRON-CHROMIUM alloys which contain silicon and 0.5-3 per cent. carbon and 5-40 per cent. chromium for use in castings resistant to acid, rust and heat, and of a high breakage resistance, have a silicon content which does not exceed more than half the carbon content. In examples the proportions are 1.8 per cent. carbon, from 34 per cent. chromium and 0.4 per cent. silicon. Alloys containing up to 28 per cent. chromium may be worked more easily if annealed at 600 to 1,000° C. After a longer or shorter annealing they can be given a desired degree of hardness by hardening and tempering, preferably at temperatures of 800 to 1,000° C. and 300 to 500° C. respectively. The alloys may also contain additions of molybdenum, tungsten, cobalt, beryllium or titanium. (See Specification 438,179, of B. Vervoort.)

### Refining Copper

MOLTEN copper is refined by over-poling until it contains 0.003-0.01 per cent. of oxygen, degasefying with lithium, and casting out of contact with air. The metal in the casting ladle is covered with glowing charcoal, and an inert gas such as carbon monoxide is introduced into the mould. The lithium may be applied either in the furnace or in the casting ladle. (See Specification 437,436, of Metall-Ges. Akt.-Ges.)

### Cementation

IRON and steel articles are carburised by heating them in a fused salt bath comprising one or more alkali or alkaline earth halides other than fluorides, together with an alkaline earth carbide such as calcium carbide. The carbide content of the bath is so adjusted as to be at least 2 per cent. calculated on the weight of the bath. The bath may consist of mixture of potassium and sodium chlorides or calcium and sodium chlorides and calcium carbide. During the working, the carbide may be added in small quantities at short intervals, e.g., additions of 2-6 per cent. by weight of the bath at half-hourly intervals. (See Specification 437,494, of A. L. H. Perry and Imperial Chemical Industries, Ltd.)

### Chemical Resistant Alloys

ALLOYS resistant to mechanical stress and chemical action comprise iron, cobalt or an iron cobalt alloy and 2 to about 10 per cent. of thorium. One or more elements which improve the properties of the alloys without modifying the action of the thorium may be added in a total proportion of about 20 per cent. to the alloys. Examples of such additions are chromium up to 20 per cent., tungsten up to 20, manganese up to 20, titanium 0.1-12, molybdenum up to 15, aluminium up to 12, or silicon up to 15. The alloys are prepared by melting in a high vacuum to prevent oxidation and the formation of other impurities. (See Specification 437,739, of W. Guertler.)







# Metallurgical Section

May 2, 1936

## Mercury for Steam Generating Plant

MERCURY amounting to 750,000 lb. or 10,000 flasks is at present circulating in three boilers and turbines driving generators in the eastern part of the United States. One of the boilers, at Schenectady, N.Y., contains 300,000 lb. of foreign-produced mercury, equivalent to about half of the production of California in 1934. This boiler is fired with powdered coal, and the pressure maintained is only 140 lb. per square inch—scarcely one-tenth that of steam at the same temperature. The boiling point of mercury is 675° F., and the boiler temperature is 975° F. A little sodium is added to the mercury to aid heat transfer between the mercury and steel, and some zirconium (or titanium) is added to retard the solution of iron from the boiler shell. A sampling and testing apparatus at the stacks checks mercury loss and is sensitive to minute quantities of mercury. The loss from the boiler and power plant is said to be 1 per cent. or 3,000 lb. a year.

The mercury vapour flows to the turbo-generators and thence to the "condenser-boilers." Here, water is used for condensing the vapour, but the latent heat of the mercury is here sufficient to generate steam at 400 lb. pressure, which is piped to an adjacent plant. The available energy in the steam so produced exceeds the power obtained from the mercury generators. The mercury circulates in the system seven times an hour. Mercury vapour from the blow-off and safety valve of the mercury boiler is led to the condenser boilers. The General Electric Co. states that there is no other known method of generating power from fuel so efficient as that represented by this mercury and steam cycle. The Schenectady installation is said to have cost about \$4,000,000, or \$200 per kilowatt capacity. Pioneering difficulties appear now to have been fairly well overcome, and within the next year or two the Emmet boiler may be used more widely, possibly in units as small as 1,000 kilowatts. Increased consumption of mercury is therefore indicated.

### World Copper Resources

SINCE 1801 the world has produced approximately 48,000,000 tons of copper; five-eighths of this amount was produced during the last 22 years and three-eighths during the last 10 years, one half of this total being contributed by the United States. World reserves of metal in the ground are estimated at 100,000,000 tons, one-fifth of which is at American mines. As no important active copper-producing district of the world has yet been exhausted, this total cannot be regarded as a possible limit. Geologic features of the occurrence of copper vary considerably throughout the world. Deposits are of four general classes: disseminated, massive sulphides or replacements, veins and bedded. The first type may be stripped or caved; the second and third types may

be mined by open-stopping, cut-and-fill, shrinkage, and other methods. Ore bodies that lie near or at the surface may be mined by open-cut or "glory-hole" methods, regardless of their physical characteristics. The average cost of producing copper during the period 9.6 cents (4.6 pence) per lb. Investment of capital in development, plant and equipment by ten North and South American companies totalled £80,000,000 to the end of 1929.

This type of information, expanded to two volumes, is to be found in "Copper Resources of the World," only recently published following upon the 16th International Geological Congress, which was held in Washington in 1933. This publication gives a survey of the copper industry—history, economics, ore occurrence, and mining methods. The copper-smelter output of the world, outside of the United States, in 1935 is estimated to be as 1,105,000 tons, 65,000 tons more than in 1934. Chile leads with 260,000 tons, Canada is next with 172,000 tons, then come Belgium and the Belgian Congo with 148,000 tons, Rhodesia 145,000 tons, Japan 67,000 tons, Russia 66,000 tons, Germany 56,000 tons, Yugoslavia 43,000 tons, Mexico 42,000 tons, and Peru 30,000 tons; Australia and other countries make up the balance of 76,000 tons.

### Beryllium in Ferrous-Base Nickel Alloys

BINARY alloys of iron and beryllium, although possessed in useful precipitation-hardening properties, are of a coarse and brittle structure, and are therefore valueless for practical use. According to W. Kroll ("Metals and Alloys," January, 1936, page 24), the addition of nickel to such alloys refines the structure and simultaneously reduces the amount of beryllium required to produce age-hardening, *e.g.*, an iron alloy containing about 5 per cent. nickel with 1 per cent. beryllium shows a fine-grained fracture, and may be hardened to over 600 Brinell. In alloys containing up to 21 per cent. nickel, the rate of chilling on quenching has an important effect on the hardening properties. Above 21 per cent. nickel, quenching at 1,100° C. followed by ageing at 450° C., does not modify the hardness of the alloy, but the use of higher temperatures produces a very considerable degree of hardening. The phenomenon is associated with the predominance, in the higher-nickel range, of the  $\gamma$ -iron state, in which beryllium is less soluble than in the  $\alpha$ -iron present in the lower-nickel alloys. The addition of chromium to nickel-iron-beryllium alloys confers no marked additional hardening capacity, but a very good degree of hardness is obtainable, *e.g.*, the alloy containing chromium 12, beryllium 1.05, nickel 6.25 per cent., gives a Brinell value of 675.

The corrosion-resisting properties of the high nickel-chromium steels is adversely affected by additions of

beryllium, but the properties of the modified steels in this respect nevertheless compare favourably with those of the straight high-chromium steels, while their superior hardening characteristics give them a distinct advantage for many purposes. An alloy containing chromium 12, nickel 7, beryllium 1 per cent., which shows a corrosion-resistance approximately equal to that of the best high-chromium steel, can be hardened to 675 Brinell as compared with a maximum of 450 for the straight-chromium alloy. Beryllium-nickel-iron alloys of the Invar type may be hardened to 350, but the low thermal coefficient of expansion is somewhat adversely affected by the beryllium addition. Kroll also draws attention to a field for research in connection with the magnetic properties of beryllium-nickel-iron alloys. He suggests that within this range of alloys it is possible that magnet steels of practical value may be found.

### Canadian Nickel-Copper Industry

TWO companies in the northern Ontario nickel-copper area of Canada, namely, The International Nickel Company and Falconbridge Nickel Mines, now supply over 80 per cent. of the world's demand for nickel, and the industry has witnessed a remarkable recovery during the past two years owing in part to the increasing application of nickel to industrial requirements associated with normal peace-time activities.

The value of the output comprising nickel, copper, platinum metals, gold and silver, selenium and tellurium, and sulphuric acid in 1935 exceeded £12,000,000. The four mines controlled by The International Nickel Company sent more than 3,000,000 tons of ore to the smelters during 1935. This company owns and operates the nickel refining plant at Port Colborne, Ontario, and has the controlling interest in the Ontario Refining Company, at Sudbury, where there is operated the largest copper refinery in Canada, with a rated annual capacity of 120,000 tons of refined copper. Falconbridge Nickel Mines is a much smaller enterprise, but has an output of upwards of 225,000 tons of ore, and exports its matte to Norway for refining. Both companies produce important quantities of platinum metals in their refining operations, whilst the mining and metallurgical processes used are perhaps more technical than those of any other metal-producing industry. The nickel-copper industry in Ontario possesses a capital investment in the province of approximately £20,000,000, apart from the estimated value of the mineral deposits themselves. By the end of 1935 the industry will have paid dividends aggregating £35,000,000, whilst at the mining, smelting and refining plants situated in the province the 6,000 workers receive about £1,800,000 annually in wages. The precious metals which are recovered from these nickel-copper deposits are refined in England.

## British Cast Iron Research Association

### New Report on Behaviour of Cast Irons

THE behaviour of five cast irons in relation to creep and growth at elevated temperatures is the subject of Bureau Report No. 144, recently published by the British Cast Iron Research Association. This report, by three members of the staff of the National Physical Laboratory (H. J. Tapsell, M. L. Becker and C. G. Conway) is the most exhaustive examination yet made in any country of the creep properties of cast iron. Five irons were chosen, in consultation with the association, which supplied the necessary material. The five irons are an ordinary engineering cast iron, a low nickel-chromium cast iron, Silal, Niresist and Nicrosilal. The report will be discussed at the May meeting of the Iron and Steel Institute, to be held in London on May 7, and the discussion will be opened by the director of the B.C.I.R.A.

Dr. J. G. A. Skerl, who has for some years past been responsible for investigatory and advisory work on moulding sands, core sands and refractory materials, has left the service of the association on March 31 to take up an industrial appointment. He will continue as a member of the Sands and Refractories Sub-Committee and the Rotary Furnace Panel.

### Visit to Fuel Research Station

The annual visit of the association to the Fuel Research Station, Greenwich, is arranged for Tuesday, June 9. Visitors will be given an opportunity of visiting laboratories and large-scale experimental plants, covering the whole range of work by H.M. Government on fuel research. Arrangements can be made for members interested to take part in this visit, but for practical reasons the number must be limited to ten, preferably those who have not hitherto seen the station. Free motor transport from East Greenwich will be available for visitors proceeding by rail from London. Members desiring to take advantage of the visit will receive invitations

direct from the Fuel Research Station, on notifying the director.

The annual conference of the Institute of British Foundrymen takes place in Glasgow and Edinburgh, June 9 to 12, when a paper will be presented on behalf of the association.

The next International Foundry Congress will take place at Düsseldorf, Germany, in September next. It is anticipated that the Foundry Conference will be held September 17 to 21, and on September 22 the autumn meeting of the Iron and Steel Institute will be held. It is understood that plans are being made for a subsequent tour of certain industrial districts in Germany, further information about which will be available later.

### Visit to German Works

Members who have visited German works in parties arranged by the association in previous years, frequently inquire when another such visit can be arranged. The probable presence in Germany of a number of members in connection with the above-mentioned meetings makes the present year a convenient time to arrange such a visit, and the director would be glad to learn how many members would be interested to join such a party, for some three or four days' visits. It will be understood that this would not in any way compete with or overlap with the arrangements made in connection with the tour mentioned above, following the International Congress, but it is probable that arrangements could be made to visit several works presenting features of interest, visits to which can be made as matters of purely business interest, without having to take into consideration the requirements of a formal tour. The Director has recently visited two German foundries, and it is certain that, where appropriate arrangements can be made, British visitors will be warmly welcomed. An indication of interest will not, of course, involve any obligation, and the party would be accompanied by the Director.



## Recent Investigations on the Corrosion of Tin

### Work of the International Tin Research and Development Council

SO many of the applications of tin are dependent upon the well-known ability of the metal to resist corrosive influences that it is not surprising that the International Tin Research and Development Council should regard the study of corrosion of tin and tin coatings as one of its main sections of research. In the Council's Technical Publication, Series A, No. 34, Mr. D. J. Macnaughtan, F.Inst.P., and Dr. E. S. Hedges, M.Sc., A.I.C., discuss the lines on which this research work is proceeding and some of the results so far obtained.

Oxygen, an important and often dominating factor in tin corrosion, is given particular study. Experiments on the atmospheric corrosion of tin have given useful information as to the type of oxide film formed. Reference is made to the theory that corrosion resistance of tin is associated with its high hydrogen overpotential so that oxidising conditions tend to diminish corrosion resistance. Aqueous alkaline solutions, it was shown in the Council's laboratories, become corrosive towards tin if air is passed through them. It is well known that if only part of the metal has access to oxygen it becomes cathodic to the parts which are not aerated, and in consequence these latter corrode preferentially. Depolarisation and the nature of the corrosion product are other factors discussed, and the authors state that while the data so far obtained are insufficient to confirm any detailed mechanism of corrosion they show that in certain cases corrosion is related to accessibility of oxygen.

Tin coatings on steel are considered separately. The Council's researches on the reversal of potential of the tin-iron couple, which has been proved to occur in many circumstances, have thrown new light on this problem. The influence of the composition and structure of the basis steel is the subject of other promising researches, and a great deal of work is proceeding on defects in the tin coating, their avoidance and remedying, and another field has been the perfecting of methods of determining porosity.

#### Atmospheric Corrosion of Tin

The corrosion of tin in both outdoor and indoor atmospheres has been investigated by the British Non-Ferrous Metals Research Association, with the support of the Tin Research and Industrial Applications Committee, by means of weight-change tests, supplemented in some cases by tests on the changes produced in tensile strength, electrical resistance, and reflectivity<sup>1</sup>. The weight-increment curve<sup>2</sup> for an initially clean sample of tin exposed to an indoor atmosphere (Fig. 1) gives useful information as to the type of film produced at the surface. The surface was prepared by scraping under acetone and was prevented from coming into contact with air before the first weighing. The curve indicates initially rapid oxidation, which soon almost ceases, as though a protective film has been formed. That this film does not preserve its protective properties is shown by the subsequent course of the weight-increment, which eventually becomes a linear increase. Thus, the air-formed film on tin has little permanent value as a protection against corrosion. Experiments on the production of films on tin by anodic polarisation in various electrolytes have likewise shown that in general such films afford only partial protection, although the possibility of producing a satisfactorily resistant film in particularly favourable circumstances is not excluded.

The rôle of oxygen in promoting the dissolution of tin is illustrated in the case of alkalis by some experiments carried

out in the Council's laboratories<sup>3</sup>. Fig. 2 shows the loss of weight, after different time intervals, of specimens of tin com-

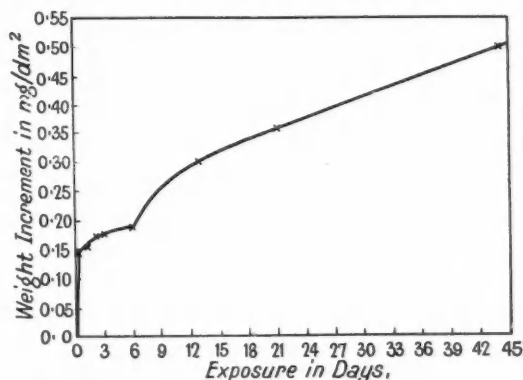


Fig. 1.—Initial Portion of the Weight-Increment-Time Curve of Tin with a Specially Prepared Clean Surface, Exposed to an Indoor Atmosphere.

pletely immersed in a solution of sodium carbonate (5 gm.  $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$  per litre) at  $70^\circ$ . The upper curve was obtained under conditions of full aeration, the solution being circulated continuously over the tin by means of an air lift. The lower curve was obtained when nitrogen (containing 0.5 per cent. of oxygen) was used in place of air. Similar results indicating marked acceleration of corrosion due to the presence of oxygen have been obtained in solutions of sodium hydroxide. If dissolved oxygen is previously removed from alkaline solutions by adding a suitable reducing agent, practically no corrosion of tin occurs.

The above facts must be taken into account in any consideration of the mechanism of corrosion of tin. Among other factors, determining the nature and extent of corrosion of metals in aqueous solutions, the following have an important influence:—

(1) Differential aeration. In accordance with this well-known principle, those parts of the metal to which oxygen has ready access become cathodic to those parts which are more sheltered from oxygen. Thus the sheltered parts are anodic and corrode preferentially.

(2) Depolarisation by atmospheric oxygen or other oxidising substances. Hydrogen momentarily produced at the cathodic portions gives rise to an e.m.f. in the reverse direction, and unless the hydrogen can be continuously removed

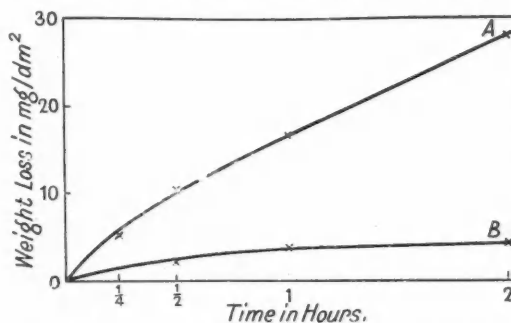


Fig. 2.—Rate of Corrosion of Tin in 0.5 per cent. Sodium Carbonate Solution at  $70^\circ\text{C}$ . (A aerated, B non-aerated).

<sup>1</sup> L. Kenworthy and J. M. Waldram, "J. Inst. Metals," 1934, 54, 247; "Tech. Publ. Internat. Tin Res. and Dev. Council," A, No. 11, 1934.

<sup>2</sup> L. Kenworthy, "Trans. Faraday Soc.," 1935, 31, 1331; "Tech. Publ. Internat. Tin Res. and Dev. Council," A, No. 24, 1935.

<sup>3</sup> R. Kerr, "J. Soc. Chem. Ind.," 1935, 54, 217 T; "Tech. Publ. Internat. Tin Res. and Dev. Council," A, No. 19, 1935.

by evolution as gas or by oxidation the system becomes polarised and further action practically ceases. Hydrogen evolution is particularly difficult from those metals which have a high hydrogen overvoltage, and with such metals it seems probable that the depolarising influence of oxygen will be more marked.

(3) The nature of the corrosion product. If the product formed at the anodic portions is soluble in the electrolyte, corrosion may proceed continuously, provided that other conditions are favourable. If the product is insoluble it will form a film, which may or may not protect the underlying metal from further corrosion, according to its continuity. Such a film may crack through physical causes and thus form a flaky growth, through which the underlying metal can be continuously attacked.

### The Effect of Three Influences

The effect of these three influences will vary from metal to metal. The effect of (1) will presumably be more marked in a metal that acquires a protective air-formed film than in one that forms a pervious film; that of (2) might be expected to preponderate in a metal having a high hydrogen overpotential rather than in one from which hydrogen is readily discharged; whilst the effect of (3) varies with the solubility and physical properties of the various compounds of the different metals.

It is interesting to consider tin in the light of these views, particularly with regard to the relative importance of the effects of (1) and (2). In view of the relatively low degree of protection afforded by the air-formed oxide film on tin and the relatively high hydrogen-overpotential at a tin cathode, it would seem that with this metal there will be a range of conditions in which the depolarising influence is likely to be predominant. This effect will probably be particularly marked in distinctly acid and alkaline solutions, in both of which hydrogen is produced, while the oxides of tin are in general soluble in both. In conditions approaching neutrality, when the oxide film is more stable, it seems more likely that corrosion will be governed by the distribution of this film. In either case the importance of the access of oxygen is clear.

The results obtained so far in the Council's researches<sup>4</sup> are inadequate to confirm any detailed mechanism of corrosion, but they are sufficient to confirm that in certain systems examined the distribution of corrosion over a specimen of tin partly immersed in the electrolyte is related to the accessibility of oxygen. Thus the behaviour of tin half immersed in 0.1 *M*- or 0.01 *M*-citric acid, with free access of atmospheric oxygen to the surface, has been observed by following measurements of electrode potential at various points on the corroding metal surface. In the technique used, a capillary tube is arranged opening on to the metal surface at the point the electrode potential of which is required; through the capillary, liquid connection is made to a standard half-cell, and the e.m.f. of the cell—tin/dilute citric acid/standard half-cell—is determined. It was found that the potential measured near the surface of the electrolyte was always about 5-10 millivolts more noble than at the lower edge. It appears that a small current of the differential aeration type must flow between the part of the specimen near the water line and the part lower down, probably accounting for the mild corrosion observed in the lower part.

### Electrochemical Relations of Tin and Iron

The industrial importance of tinned steel has encouraged considerable activity in recent years in the investigation of the conditions of corrosion of tin, iron, tinplate and the tin-iron couple in various aqueous solutions, notably those of weak organic acids of the type found in foodstuffs. This field of investigation presents certain differences from the study of the corrosion of tin, in that the steel base is not

as a rule entirely covered with tin, but is exposed, at minute discontinuities or pores in the tin coating. Such discontinuities form local electrolytic cells, the behaviour of which it is clearly of the utmost importance to investigate as part of any comprehensive understanding of the corrosion-resisting properties of tinned steel.

According to the standard electrode potentials of tin and steel, it might be expected that the existence of discontinuities in the tin coating would lead to serious local corrosion of the exposed steel, which would function as anodes, the surrounding tin being cathodic. Although this does happen under certain conditions, leading to perforation of the sheet at the sites of such pores, it has been known for some time that in many circumstances the potential of the tin-iron couple is reversed, tin becoming anodic to iron. Under such conditions the attack is not localised at small areas, but is spread over a large surface, and the tinplate gives more useful service.

The value of tinplate as a container for foodstuffs is due in no small measure to this facility of the system to reverse the usual potential relations.

Different explanations of this phenomenon have been advanced, the reversal of potential being ascribed to the formation of an oxide film on iron, the dissolution of an oxide film on tin or the high hydrogen-overpotential of tin. In spite of this work the fundamental features of the process have not been completely understood.

New light is thrown on this problem as the result of the Council's recent researches<sup>5</sup>, in which the potentials of tin and iron immersed in dilute acid solutions have been measured after successive short time intervals. A typical result is that illustrated in Fig. 3, which shows the time-potential curves of tin and iron immediately after immersion in 0.1 *M*-oxalic acid. The initially high potentials rapidly fall to low values, the fall for tin being greater than that for iron. In the light of previous, well-established work it is reasonably certain that this initial effect is due to the breakdown of the original air-formed oxide films on both metals. No subsequent rise of potential with time was observed, indicating that no secondary film is built up.

Whilst this result is of interest in showing how the relative potentials of tin and iron are affected by the presence or absence of oxide films on both metals, thus illustrating the reversal of potential which may occur after a short time, it does not in itself explain the inversion of potential (i.e., why tin is anodic to iron when the steady state is reached). This further point is clarified, however, when similar potential curves obtained in other electrolytes are examined.

As an example the potential curves for tin and iron in 0.01 *M*-sulphuric acid may be considered (Fig. 4). Again the rapid initial fall of potential, due to the dissolution

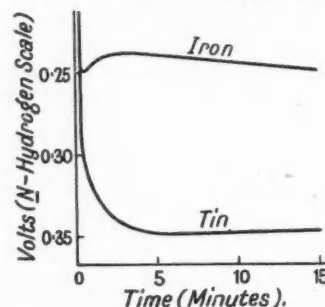


Fig. 3.—Potentials of Tin and Iron in 0.1 *M*-citric Acid (p 1.97).

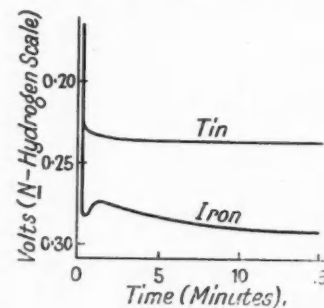


Fig. 4.—Potentials of Tin and Iron in 0.01 *M*-sulphuric Acid (p 1.81).

<sup>4</sup> T. P. Hoar, "J. Inst. Metals," 1934, 55, 135; "Tech. Publ. Internat. Tin Res. and Dev. Council," A, No. 4, 1934.

<sup>5</sup> T. P. Hoar, "Trans. Faraday Soc.," 1934, 30, 472; "Tech. Publ. Internat. Tin Res. and Dev. Council," A, No. 5, 1934.

of oxide films on both metals, is observed, but in this case when the steady state is reached tin is cathodic to iron, in accordance with its normal position in the electrochemical series. The corroding potential of tin in this experiment (-0.23 volt) is not far removed from the standard electrode potential of tin on the normal hydrogen scale (-0.136 volt), whilst in the experiment in oxalic acid it is considerably lower (-0.35 volt). Experiments in 0.1 *M*-citric acid and in 0.1 *M*-citric acid-sodium citrate buffer (*pH* 5.10) also gave remarkably low corroding potentials for tin (-0.29 and -0.45 volt respectively). Such low potentials correspond with exceedingly low activities of stannous ions near the electrode surface. These features may be ascribed to the formation of stable anionic stannous-complexes in oxalic and citric acids, whilst in the sulphuric acid solution tin enters mainly as simple stannous ions. Migration experiments confirm the existence of the citrate and oxalate complexes. In 0.1 *M*-perchloric acid, where there is little tendency to the formation of complex anions containing tin, the corroding potential was determined as -0.20 volt, and inversion of the electrochemical relations of tin and iron does not occur.

To summarise these observations it appears that when tin and iron are immersed in dilute acids they show initially noble potentials, and as the oxide films covering both metals dissolve the potentials of both electrodes fall to values characteristic of the bare metals. If simple ions are formed the tin is cathodic to iron, but if the electrolyte is such that stable tin complexes are formed the potential of tin is reduced to a value below that of iron, and tin acts as anode. Thus the major factors determining the polarity of the tin-iron couple are (1) the presence or absence of oxide films on both metals, and (2) the ability of the electrolyte to remove stannous ions as complexes. More recent work has shown that yet another factor is the presence of tin ions in the solution, the effect of which on the potential of steel may be sufficiently marked to render it anodic or cathodic to tin.

#### Influence of Defects in the Coating

The corrosion behaviour of tinned steel is more complex than that of tin. Thus, in addition to the normal tin surface, minute exposed areas of steel or of the tin-iron alloy, which forms a layer between the outer tin coating and steel base, have to be considered, particularly in the light of the electrochemical behaviour mentioned above. A section of the Council's researches has been directed, therefore, to an investigation of the conditions governing uniformity of the coating. The pores which are normally found in such coatings are of particular importance and are discussed separately below; the cause of their formation is a problem which is essentially a part of a comprehensive study of corrosion; with regard to their origin, at present it is only possible to state that all the stages of tinplate manufacture are under examination with a view to tracing the sources of this defect.

Normally the corrosion resistance of tinned steel is enhanced by increasing the thickness of the coating. To facilitate work in this direction a rapid method for determining the thickness of tin coatings on steel has been developed.<sup>6</sup>

When a very thin coating is applied to steel by hot-dipping it frequently happens that a considerable number of areas of exposed tin-iron alloy are visible. When the thickness of tin is increased these patches are covered up. The presence of tin-iron alloy in the surface may also be due to other causes. It may be exposed at certain points in the "grease lines" which are formed in a direction parallel to tinning, apparently due to stripping of the molten tin by runnels of oil formed in the top pair of grease-pot rolls. Microscopical observation<sup>7</sup> has also shown that crystallites of FeSn<sub>2</sub>, not contiguous with the alloy layer at the junction

of the steel base and the tin coating, may be present in the tin coating. These crystallites are probably picked up from the tinning bath, in which FeSn<sub>2</sub> is formed by dissolution and reaction of the steel sheets and iron container with the molten tin.

The electrochemical behaviour of the tin-iron alloy in couple with tin or iron has not yet been studied in detail, but the general features observed seem to indicate that the alloy itself has considerable corrosion resistance. The brittleness of this alloy, however, is a factor which may lead to corrosion of the underlying steel. During fabrication the tin coating readily suffers deformation without fracture, but the brittle alloy layer is easily broken. In parts of the sheet at which the tin-iron alloy is exposed, the steel base will be exposed through cracks in the alloy layer formed in bending, and in suitable conditions corrosion will be enhanced. This has been shown to occur due to bending at the sites of the defects discussed above.

#### Non-Uniform Tin Coatings

Studies are also being made by the Council<sup>8</sup> on other causes of non-uniform tin coatings, not only on steel but on other metals. When a sheet of metal is withdrawn from a bath of molten tin the liquid layer is smooth; on cooling a smooth solid coating may be obtained, but in some circumstances the coating is rippled, the tin accumulating in low ridges. It has been found that the addition of small amounts of other metals to the molten tin has a marked influence on the formation of a smooth coating. The influences of these factors on corrosion are a subject for investigation. Another factor which may influence corrosion in special circumstances is the appearance of spangles under certain conditions of tinning. It has been found that the spangle is influenced considerably by the presence of small quantities of other metals in the molten tin.

The foregoing considerations apply to hot-tinned coatings. Investigations are also at present in progress on the corrosion resistance of electrodeposited tin coatings, and it is proposed to extend the work to coatings formed by spraying. The factors determining corrosion in such coatings are not entirely the same, owing to the absence of the alloy layer and to structural differences, while discontinuities are associated with different origins. In connection with this work an electro-tinning bath, which is characterised by excellent throwing power, thus giving remarkably uniform deposits on articles of complicated design, has been devised.<sup>9</sup> It has also been found that the corrosion resistance of hot-tinned coatings can be increased by the subsequent applications of a thin electrodeposit of tin, thus filling up original discontinuities in the coating.<sup>10</sup>

#### Determination of Tinplate Porosity

A method of testing the porosity of tin coatings on steel has been developed in the Council's researches,<sup>11</sup> which gives more consistent and trustworthy results than the earlier ferricyanide-paper test. The new hot-water test thus devised consists in keeping the degreased tinplate in hot distilled water (within a certain pH range) for some hours, when adherent rust spots form at the pore sites, rendering them clearly visible. This method is now becoming extensively used in commercial and research laboratories as a standard procedure for determining porosity.

<sup>6</sup> E. J. Daniels, "Trans. Faraday Soc.," 1935, 31, 1277; "Tech. Publ. Internat. Tin Res. and Dev. Council," A, No. 17, 1935.

<sup>7</sup> A. W. Hotherhall, S. G. Clarke and D. J. Macnaughtan, "J. Electrodepositors' Tech. Soc.," 1934, 9, 101; "Tech. Publ. Internat. Tin Res. and Dev. Council," A, No. 1, 1934.

<sup>8</sup> D. J. Macnaughtan, Brit. Pat. No. 417,411 (1934); A. W. Hotherhall and W. N. Bradshaw, "J. Soc. Chem. Ind.," 1935, 54, 320; "Tech. Publ. Internat. Tin Res. and Dev. Council," A, No. 22, 1935.

<sup>9</sup> D. J. Macnaughtan, S. G. Clarke, and J. C. Prytherch, "J. Iron & Steel Inst.," 1932, 125, 159; "Tech. Publ. Internat. Tin Res. and Dev. Council," A, No. 7, 1935.

<sup>6</sup> S. G. Clarke, "Analyst," 1934, 59, 525-8; "Tech. Publ. Internat. Tin Res. and Dev. Council," A, No. 12, 1934.

<sup>7</sup> W. E. Hoare, "J. Iron & Steel Inst.," 1934, 129, 253; "Tech. Publ. Internat. Tin Res. and Dev. Council," A, No. 2, 1934; "Proc. Swansea Tech. Coll. Met. Soc.," Dec. 15, 1934; "Tech. Publ. Internat. Tin Res. and Dev. Council," A, No. 14, 1934.



## Recent Metallurgical Patents

### Iron and Steel Alloys

IN the production of iron and steel alloys containing metals such as chromium, manganese, vanadium or tungsten by processes of the kind in which ores are directly reduced, and wherein the ore is in excess relatively to the reducing agent, an excess of the order of 10-40 per cent. is used, and the silicon content of the high-silicon product is lowered to the required amount by treatment of the bath with an oxidising slag which may consist of iron ore, magnetic concentrates or mill scale, with or without lime. A finishing treatment with a refining slag may be applied. The temperature of the bath during removal of the silicon may be 2,800-3,000° F. The molten iron or steel bath may contain alloy scrap, the high silicon content of which is lowered by the oxidising and refining treatment. (See Specification 437,806, of A. H. Wild.)

### Coating with Metals

APPARATUS for cracking liquid carbonaceous materials or for effecting chemical reactions with carbon monoxide, *e.g.*, the preparation of metal carbonyls, is constructed of iron or alloy steel the inner surfaces of which are coated with an iron-zinc alloy by covering them with zinc and heating to 400-800° C., or by heating to a temperature between the melting point of zinc and 900° C., in contact with zinc vapour. The apparatus may be embedded in zinc powder or in molten zinc or sprayed with zinc if desired in the presence of inert gases, *e.g.*, hydrogen, nitrogen or carbon dioxide to exclude oxygen. The apparatus may first be treated at 800° C., and then at 600° C. Petroleum containing 5 per cent. sulphur is cracked at 500° C., in a pipe coated with zinc alloy by charging the pipe with 25 parts zinc powder and 75 parts alumina and then heating the pipe for 50 hours to 900° C., in a chamber from which air is excluded. (See Specification 437,678, of I. G. Farbenindustrie.)

### Rustless Iron

IN a method of making rustless or stainless iron in an electric arc furnace by melting down a charge consisting principally of chromium-containing rustless scrap and an oxidising agent to form an iron bath containing chromium and a blanket of slag containing the oxides of iron and chromium and then reducing the chromium oxide contained in the slag, the reducing agent used is one containing combined chromium such as ferrochrome silicon. The melting of the charge is performed continuously and the reducing agent is added while the metal and slag are at a temperature of super-heat, *e.g.*, 3,050-3,200° F. The oxidising agent used may be iron oxide in the form of roll scale or magnetic iron ore concentrate and the furnace is provided with a chromite lining. The rustless irons prepared usually contain 12-20 per cent. or more of chromium and .05-.15 of carbon, and may also contain up to 20 per cent. of nickel, up to 5 of copper molybdenum and tungsten and up to 2 of vanadium. (See Specification 437,186, of W. W. Triggs, Alloy Research Corporation.)

THE statement of affairs of David Ronald Tullis, a metallurgist, of Somerfield, Manor Drive, Sutton Coldfield, whose creditors met in Birmingham on April 28, showed £4,281 liabilities expected to rank for dividend. Assets were estimated at £96, leaving a deficiency of £4,185. Tullis formerly carried on business at Rainhill, Liverpool, under the name of Percy Oakley, patentees. He attributed his failure to loss of moneys lent by the partnership of which he was a member to a company which subsequently failed, the loss of guarantees given by the company, and also to the loss of £3,000 he had invested personally in the same company. The matter was left in the hands of the Official Receiver.

## Iron and Steel Institute

### Annual Meeting, 1936

THE annual meeting of the Iron and Steel Institute will be held, by kind permission, at the Institution of Civil Engineers, Great George Street, Westminster, S.W.1, on Thursday and Friday, May 7 and 8. The sessions will open each day at 10 a.m.; there will be an afternoon session on Thursday, May 7, only.

On Thursday morning, May 7, following the presentation of the annual report and statement of accounts for 1935, and the presentation of the Bessemer Gold Medal to Mr. Fred Clements, the following papers will be presented for discussion:—G. A. V. Russell: "Some Considerations Influencing Plant Facilities for Strip-Sheet Production under British Conditions." C. A. Edwards, F.R.S., and others: "A Study of the Influence of Varying Degrees of Cold-Rolling and Annealing Temperatures on the Properties of Mild Steel Sheets." J. H. Whiteley: "A Survey of the Iron-Carbon Diagram near Zero Carbon (below 1000°C.)." W. E. Goodrich: "The Embrittlement of High Tensile Alloy Steels at Elevated Temperatures."

On Thursday afternoon the following papers will be presented for discussion:—H. J. Tapsell, M. L. Becker and C. G. Conway: "The Behaviour of Five Cast Irons in Relation to Creep and Growth at Elevated Temperatures." M. L. Becker and C. E. Phillips: "Internal Stresses and their Effect on Fatigue Resistance of Spring Steels." G. A. Hankins, M. L. Becker and H. R. Mills: "Further Experiments on the Effect of Surface Conditions on the Fatigue Resistance of Spring Steels."

### Carnegie Research Scholarships

On Friday morning, May 8, an announcement of the award of the Andrew Carnegie Research Scholarships for 1936 will be made, followed by the announcement of the award of the Carnegie Gold Medal and the Williams Prize. The following papers will then be presented for discussion:—C. O. Bannister and R. Rigby: "The Influence of Light on the Electrode Potential and Corrosion Phenomena of Mild Steel." T. P. Hoar and D. Havenhand: "Factors Influencing the Rate of Attack of Mild Steels by Typical Weak Acid Media." A. W. Hotherhall and W. N. Bradshaw: "Methods of Detinning Tinplate for Examination of the Thickness and Continuity of the Alloy Layer." A. W. Hotherhall and J. C. Prytherch: "A Study of the Origin of Porosity in the Tin Coating of Tinplate."

The annual dinner of the Institute will be held in the Grand Hall of the Connaught Rooms, Great Queen Street, W.C., on Thursday, May 7, at 7 for 7.30 p.m. Applications for tickets (price 15s. each, exclusive of wine) should be made not later than April 30.

### A New Publication on Heat Treatment

THERE has been, in the past few years, an enormous increase in the application of salt baths to the heat treatment or carburisation of metal parts. This is to be attributed, in this country at least, to the activities of Imperial Chemical Industries, Ltd., which has always pursued a policy at every opportunity of spreading knowledge conducive to the more efficient application of its products. Such a policy has three principal requirements: a continuous programme of research, a system of advice and technical service to customers, and a scheme for disseminating knowledge. It is in the interests of the last that the Cassel Cyanide Co., a subsidiary of I.C.I., are publishing a new bulletin entitled "Heat Treatment." This bulletin will appear at intervals, and will deal with every aspect of salt bath applications to colour tempering and casehardening. It is being published in the belief that its subject-matter will be of interest and value to engineers, metallurgists, physicists and chemists who have problems coming within its range.







# Metallurgical Section

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June 6, 1936

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## Corrosion Research on Nickel Alloy Steel

THE 15th report of the special committee of the Institution of Civil Engineers engaged in the investigation of the corrosion of metals, timber and concrete when exposed to marine atmospheres and different forms of sea water attack, contains a summary of the work of the committee since its inception in 1920. Test conditions have embraced aerial exposure, and half tide and complete immersion in salt and fresh water, on individual specimens and on coupled bars. The conclusions which may be drawn from the results so far obtained are especially interesting and varied. Maximum differences in the resistance of the different metals to corrosion was shown in aerial and fresh water tests, but under half-tide and complete immersion conditions behaviour was more closely similar. The mean resistance of the wrought irons and carbon steels to the various types of corrosion was approximately equal. Under all conditions of exposure, however, the presence of mill-scale markedly accentuated susceptibility to localised corrosion. Cast irons gave good resistance to aerial and fresh water attack. The addition of 0.6 and 2.2 per cent. of copper to mild steel gave noticeably increased resistance in aerial and fresh water, but not in half-tide and complete sea-water immersion conditions. High-chromium steel showed satisfactory resistance to atmospheric and fresh-water corrosion, but under half-tide and complete immersion conditions, suffered severe localised corrosion. The addition of 3.75 per cent. of nickel to 0.31 per cent. carbon steel markedly enhanced resistance to aerial and fresh water attack. Steel containing 36.6 per cent. of nickel was, in all conditions, the most resistant of the materials tested, and also showed comparative freedom from pitting. Contact between dissimilar metals had no pronounced influence in aerial tests; under the other conditions studied it was found that ordinary mild steel in contact with wrought iron was partially preserved at the expense of the wrought iron, and that high-nickel or high-chromium steel in contact with plain carbon steel was protected at the expense of the unalloyed steel.

### International Control of Metal Supplies

DR. C. H. DESCH, Superintendent of the Department of Metallurgy at the National Physical Laboratory, ventured to make a suggestion of international importance when he delivered one of the Ludwig Mond lectures at Manchester University, last month. Speaking of the "Place of Metals in Civilisation," he spoke of the need of access to ample supplies of a variety of metals for a country engaged in warfare, and remarked that it had been urged that this dependence of the war-maker on mineral supplies provided in itself an important means of guaranteeing peace. Sir Thomas Holland, he said, had shown that no single nation was self-contained in mineral resources, and that even the

largest and most powerful were dependent on outside sources for certain essential minerals. In consequence, "mineral sanctions" would deprive an aggressor nation of all imports of essential minerals, but would inflict no hardship on the civil population. Apart from this question of war supplies, however, the rapid consumption of mineral resources presented a social problem which must sooner or later receive the serious attention of statesmen throughout the world. The reserves of mineral deposits were large, but by no means inexhaustible. Of some metals the available reserves were known to be strictly limited, and if the present rate of consumption continued their exhaustion could be predicted. If, therefore, we find that metals are essential to modern civilisation, that the quantities in which they are available are limited, and that their uncontrolled exploitation is not only wasteful, but may be used in a destructive capacity by an aggressor nation, it would seem perfectly logical that some international plan for regulating their production and distribution should come into existence.

### The Scrap Metals Industry

By reason of present economic conditions, the old-metal trade in Germany has been reduced to a state of utter helplessness. Metal consumers and foundries are now procuring their scrap as best they can, even to making the collection of small accumulations. The practice of shops trading their clippings, turnings, and other scrap for new metal has also become more general. In Great Britain more scrap is also being utilised, and a shortage is possible. Consumption in 1935 was about 5,000,000 tons, of which 3,750,000 to 4,000,000 tons was old metal. Imports were 436,000 tons, a gain of 90,000 tons over those of 1934, and exports were 168,000 tons, a decline of 65,000 tons. The sources of British domestic scrap are chiefly old ships, old works and heavy machinery. The scrap industry of Holland has also grown slowly and irregularly in recent years. In 1934 there were 17 establishments engaged in breaking up ships and machinery for the recovery of metal, but only eight in 1926. The output of iron and steel scrap increased from 15,600 to 37,100 metric tons during this period. Germany takes about half the ferrous scrap, with Poland and Danzig as other important buyers. Belgium and Luxemburg are leading purchasers of lead and zinc; France buys zinc and nickel.

In the United States the value of metals reclaimed annually from scrap rivals the value of virgin metals won from the ground. Secondary metals exert a stabilising influence on metal prices, and the magnitude of the secondary metal industry is revealed by the enormous tonnage produced, which for copper, lead, and zinc has been recorded over a period of twenty

years. Trends in the growth of secondary production of individual metals vary according to the degree to which the metal is dissipated in use; the scrap from aluminium is growing fast, and although that from zinc has been constant, it may increase from die castings.

### Detinning Scrap Tinplate

THE standard method of detinning tinplate scrap for the recovery of the tin has been to treat the scrap with chlorine to convert the tin to tin chloride. According to a newer process evolved in Holland the detinning operations are much simplified and rendered less dangerous by using acetic acid in place of chlorine. By heating tinplate in a closed chamber containing acetic acid vapour, the tin is attacked and a white layer of small water-soluble crystals is formed on the surface, the iron base not being attacked. The acid reacts with the tin at ordinary temperatures, although heating is desirable to speed up the reaction. Formic acid may also be used in place of acetic acid. Another new process, based on an electro-chemical reaction, has been evolved in the United States, and here the tin is removed by treatment with a solution and is then recovered electrolytically. The detinning bath consists of a weak solution of alkali, containing oxides of nitrogen. After the bath is exhausted and contains sufficient dissolved tin the solution is electrolysed to recover metallic tin and to regenerate the alkaline solution. This solution is then treated with oxides of nitrogen and re-circulated for further use. Both sodium

and potassium salts are suitable for making the detinning bath, the loss of alkali being very small as the solution is constantly regenerated. Employing the same bath for dissolving and recovering the tin in the metallic state seems to be novel and has proved of considerable economic and practical value.

### Sealing Metals into Glass

THE development of sealed-off gaseous conduction devices in the electrical industry has created a demand for a metal which seals into hard glass, is resistant to attack by mercury, can be readily machined, and is not unduly expensive. An iron-nickel-cobalt alloy, containing about 29 per cent. nickel, 17 per cent. cobalt, 0.2 per cent. manganese, the balance being iron, is said to meet these exacting requirements. Its expansivity over the range 25° to 325° C. is  $4.0 \times 10^{-6}$ , while that of the glass most usually employed is  $3.6 \times 10^{-6}$ . An increase in the proportion of cobalt decreases the coefficient of expansion, but a limit is set by the counter-vailing disadvantage that it raises the temperature of the  $\text{Ar}_3$  transformation of the iron. This disadvantage can be overcome by the addition of small amounts of manganese and carbon, but, except in the case of the latter, the addition elements do more harm to the expansion properties than good in the other direction. The addition of manganese is made to improve the machining properties, while carbon is excluded because, during sealing, the alloy oxidises superficially, and, if carbon be present it reduces these oxides, causing the formation of bubbles of  $\text{CO}_2$  round the wire.

## Dependence of Engineering Advance on Metallurgical Research

### Recent Developments and their Influence

**M**ONSIEUR Charles-Eugène Schneider, governing director of Schneider et Cie, Le Creusot, discussed before the Institution of Civil Engineers, on May 26, the important part which metallurgy has played in connection with advances in engineering practice. He pointed out that the present year was the hundredth anniversary of the taking over of Creusot works by his grandfather, who was responsible for their large and rapid development. Since that time, those in charge of the works had never ceased to entertain friendly relations with the British iron and steel industry and to exchange ideas and results of experiments and discoveries with British metallurgists.

M. Schneider said that in 1836 the metallurgy of iron was in a process of evolution, and many works still used old methods. France was then the second metallurgical country in Europe, the first place being occupied by England, whose output of pig iron and wrought iron was equal to that of the rest of the world. Of the 543 furnaces in blast in France, 502 were fired with charcoal, and their output was restricted by the output of the forests. The old forges had to be located near forests and on the banks of rapid flowing streams suitable for working the hearth bellows and small mechanical hammers by water wheels. The introduction of the use of coal in the manufacture of pig iron led to a complete change in methods of working and the location of plants. In 1836, his company owned four coke blast furnaces and produced 7,000 tons of iron in bars and plate, whilst the total production of steel for making such things as tools and arms in France was about 6,000 tons.

Those responsible for the introduction of new ideas were limited by the facilities available, but during the last century new processes and new appliances had placed at the disposal of engineers facilities of the highest importance. The electrical furnace, introduced in 1900, meant for the refined and special steel industry an advance similar to that afforded by the Bessemer converter in the manufacture of ordinary classes of steel. The era of electricity also radically transformed the rolling mills. Whilst in 1865 the Creusot works needed twenty-six rolling mill sets to roll 100,000 tons per annum, in a modern steel works of one million tons capacity to-day, five graded sets would suffice for producing all the usual bar sections.

Quality improved at the same time as quantity. In 1885, two Creusot scientists, Osmond and Werth, established the proof of the *cellular* and crystalline structures of steel and alloys with the aid of photography, and the relations existing between the state of the constituents of steel and its mechanical properties, together with the influence of variations of temperature upon the state of the constituents of steel, formed the subject of researches by many other scientists. New methods of metallographic investigation were completed by resorting to oblique illumination, which enabled the identification of certain inclusions otherwise invisible.

M. Schneider referred to the study being carried out in French laboratories of micro-analytical processes, with a view to investigating micro-segregation. New testing machines due to M. Chévenard enabled the determination of the mechanical characteristics of a small piece of metal and

proved most useful in autogenous welding technique. Corrosion tests, mechanical tests in the hot state, and repeated torsion and bending tests supplied data which was absolutely essential to-day for the engineer. X-ray examination enabled information to be obtained concerning the homogeneity of steel, and was proving most useful for the verification of welds in plate work. He mentioned also the spectrographic analysis of an X-ray beam to determine with certainty the limits of solid solutions, to study definite compounds and their crystalline system, and to throw light upon the phenomenon of cold working or re-crystallisation. This exploring of the microscopic particles would procure data of the highest interest on special steels, on methods of forging and also on the heat treatments which were most suitable for their different uses.

### Increasing Hardness

In connection with alloys, he said that nickel was the best alloy metal to act upon the critical range of quenching, since it increased hardness without making for brittleness and allowed of decreasing the percentage of carbon when an increase in hardness was not desired. The use of chromium, the addition of molybdenum and of titanium, the perfecting of thermal treatment and of pickling, and the smoothing of the surfaces, all combined, had enabled metallurgy to offer to the chemical industry a whole series of steels having notable mechanical properties, which could be worked up, machined and welded, and were at the same time capable of resisting for long periods the strongest chemical reagents. Among these steels the best known and most commonly used was one having an austenitic structure containing 18 per cent. of chromium and 8 per cent. of nickel.

Work carried out by metallurgists in the study of steel showed satisfactory resistance at high temperatures both to mechanical stresses and to oxidation. Chromium steels containing a certain proportion of nickel, tungsten and vanadium would withstand temperatures of even 2,000° F. The motor car and aeroplane owed many of their recent advances to the results obtained by metallurgists. Recent military aviation engines weighed hardly 1.1 lb. per h.p., and there had been a corresponding decrease in the weight of the framework due to the manufacture of a whole series of light alloys having a specific gravity of 2 to 3 and a strength comparable to that of mild steel.

### Use of Special Steels

The length of round wire which could bear its own weight had increased from 2.5 miles for puddled iron wire and 3.3 miles for mild steel wire to about 15 miles for wire of special nickel-chromium-tungsten steel. The use of special steels had also led to an increase in span in cantilever and suspension bridges, to making possible still deeper winding depths in collieries, and to improvements in the design of internal combustion engines and turbines. In connection with turbine shafts, one of the special conditions that had to be observed in their manufacture was to prevent any possibility of their undergoing deformation at their actual working temperatures. This meant that no residual stress should remain in them following thermal treatment. In France, Mesnager and Jouguet discovered methods to arrive at the residual stress in question, but these were costly and took time. His firm had, however, perfected an approximate method called the "prism method," which consisted of measuring the deformation of a test prism in the course of machining. This permitted in every case the determination of the type of treatment required.

M. Schneider is a descendant of a family of ironmasters. His grandfather, Joseph-Eugène Schneider (1805-1875), himself an ironmaster at Bazeilles in the north of France, was a Cabinet Minister and president of the Legislative Corps during the reign of Napoleon III, and a member of the Emperor's Privy Council. At the beginning of the last century he acquired the old Royal Iron Foundries at Le

Creusot, which were built in 1782 under the patronage of King Louis XVI, and founded the present firm of Schneider et Cie. M. Schneider himself, as soon as he had completed his studies and finished his military service, joined his father, Henri Schneider (1840-1898), who, during his lifetime, was responsible for a large development of the Schneider Works. He is a past-president of the Iron and Steel Institute, honorary member of the American Iron and Steel Institute, and Freeman of the Worshipful Company of Blacksmiths. He holds the following Gold Medals: Bessemer Medal (Iron and Steel Institute), John Fritz Medal and the Medal of the American Institute of Mining and Metallurgical Engineers (United States).

## United States Cadmium Industry

### Sharp Increase in Price

THE production of metallic cadmium in the United States in 1935 amounted to 3,477,901 lb., an increase of 25 per cent. over the output of 2,777,384 lb. in 1935. Output in 1935 was the largest annual production ever recorded. Stocks of metal were drawn upon and sales amounted to an all-time high record of 4,023,900 lb., an increase of 63 per cent. over sales of 2,472,971 lb. in 1934. The average quoted price for cadmium stood at 55 cents per lb. for several years. It advanced sharply to 65 cents in late March, 1935. Other sharp increases took place later in the year and carried the price to \$1.05 per lb. in December, 1935, nearly double the level at which it stood as the year began.

In addition to metallic cadmium domestic manufacturers reported production of the following cadmium compounds: cadmium sulphide, cadmium oxide, cadmium lithopone, cadmium selenide (cadmium red), cadmium hydrate, cadmium chloride, cadmium carbonate, and cadmium sulphate—the cadmium content of which was 507,400 lb. in 1935, compared with 566,700 lb. of cadmium in compounds in 1934, a decrease of 10 per cent. Imports of cadmium metal for consumption in the United States in 1935 amounted to 185,387 lb., of which 71,147 lb. were from Belgium, 54,046 lb. from Norway, 33,580 lb. from France, 11,649 lb. from United Kingdom, 10,516 lb. from Canada, 4,409 lb. from Netherlands, and 22 lb. from Germany. Imports in 1934 totalled 125,955 lb.

## Research on Tinsplate

### De-Tinning to Expose the Tin-iron Alloy Layer

IN studying the continuity, structure, and behaviour on deformation of the alloy layer on tinsplate, it is necessary to remove the coating of tin without attacking the underlying layer of tin-iron alloy or any exposed steel. This may be done by means of sodium plumbite or aqua regia, but in addition a new electrolytic method has now been devised by A. W. Hothersall and W. N. Bradshaw. In Technical Publication, Series A, No. 37, of the International Tin Research and Development Council they describe their experiments with these methods, and they have investigated the thickness, appearance and continuity of the alloy layer on tinsplate of various grades. The electrolytic method consists in anodic treatment in 5 per cent. sodium hydroxide solution at 30° C. under a controlled potential difference and takes from 10-20 minutes.

It is noted that the thickness of the alloy layer agrees closely with that found by other workers for different grades of tinsplate, but if the plates have heavier coatings than usual, as a result of being re-immersed in molten tin, there is a considerable variation in the thickness of the alloy layer, which indicates that the time of re-immersion allowed in practice is very variable.



## The Iron and Steel Institute

### Summaries of Papers presented at the Annual Meeting

ONE of the principal papers presented at the annual meeting of the Iron and Steel Institute, held in London on May 7 and 8, was that on "Methods of Detinning Tinplate for Examination of the Thickness and Continuity of the Alloy Layer," by Mr. A. W. Hothersall and Mr. W. N. Bradshaw (Woolwich). By arrangement with the British Non-Ferrous Metals Research Association the work described in the paper was carried out at the Woolwich Research Department with the aid of funds provided by the International Tin Research and Development Council. The authors had examined the sodium plumbite method and a new electrolytic method of detinning tinplate to determine the conditions of minimum attack on the alloy layer. The thickness and porosity of alloy layers on commercial tinplates were examined by the methods developed.

#### The Sodium Plumbite Method

Detinning by the sodium plumbite method involves immersion in the boiling solution for a period of 3-5 minutes. With an unsuitable composition of solution the alloy layer was markedly attacked, or removal of the tin was slow; with the optimum composition of solution, about 3 per cent. of the alloyed tin present on an average grade of tinplate was dissolved per minute. The usual time for which the alloy is exposed to attack by the solution is 2-3 minutes. A recommended procedure is given in the paper.

The electrolytic method consists in anodic treatment in 5 per cent. sodium hydroxide solution at 30° C.; the potential difference across the cell is controlled and should not exceed 1.0 V. Detinning of an average quality tinplate takes 10-20 minutes. The attack on the alloy layer in 5 minutes amounted to 1.4 per cent. of the alloyed tin present on an average grade of tinplate. In agreement with previously published results, an average of 3.3 oz. of alloyed tin per basis box (2.3 g. per sq. m.) was found on tinplate carrying 2 lb. or less of tin per basis box (22.4 g. per sq. m.). Larger amounts of alloyed tin were found on plates having tin yields in excess of 3 lb. per basis box (33.6 g. per sq. m.), the maximum figure obtained for commercial tinplate being 1 lb. 1.2 oz. of alloyed tin per basis box (12 g. per sq. m.). The heavier alloy layers did not show the mottled pattern typical of the average grade of alloy layer.

The alloy layer of average quality tinplate was found to be highly porous (30,000-70,000 pores per sq. dm.), using both the hot-water and ferroxyl tests. The heavier alloy layers were less porous.

Determinations of the tin yield of heavily coated tinplates by Clarke's method of stripping in hydrochloric acid containing antimony are liable to a slight error when the amount of alloyed tin exceeds the average, because of the altered correction factor required for dissolution of the alloy layer; in an extreme case, this error may amount to 5-6 per cent. of the total tin yield. No modification of the correction factor is involved for tinplate carrying less than about 3 lb. of tin per basis box.

#### Effect of Light on Corrosion

Mr. C. O. Bannister, M.Eng., A.R.S.M., and Dr. R. Rigby, B.Eng., Ph.D. (Liverpool University) presented a paper on "The Influence of Light on the Electrode Potential and Corrosion Phenomena of Mild Steel." A review was given of previous work on the effect of light on the corrosion of iron and steel. For the work described in the paper an apparatus was used which allowed of perfect control over the oxygen supply to the specimens under examination, the differences of potential between illuminated and non-illuminated specimens being registered by means of a thread recorder. Only slight differences were recorded in the absence of oxygen, but on

aerating the electrode to the illuminated a marked response to illumination was shown. A record showing variations over four days was given; during the first two days the illuminated electrode became more cathodic, and during the second two days it becomes more anodic. The probable mechanism of the reactions was given, and a short comparison of the results with those obtained in the case of certain non-ferrous metals was added.

#### Internal Stresses

Dr. M. L. Backer, B.Met., Ph.D., and C. E. Phillips, A.C.G.I., D.I.C. (National Physical Laboratory) presented a paper on "Internal Stresses and their Effect on the Fatigue Resistance of Spring Steels." This work was part of a comprehensive investigation carried out at the National Physical Laboratory on the effects of surface conditions on the fatigue resistance of steels. Methods of improving the fatigue resistance of unmachined steels are also included in the programme.

Preliminary internal stress measurements were carried out on a silico-manganese steel, a 0.6 per cent. carbon steel, and a 5 per cent. nickel steel, case-hardened. It was found that quenching from the tempering temperature induced compressive stresses near the surface of a spring plate. Fatigue tests were carried out on chromium-vanadium and low-chromium steels, with various conditions of surface, to determine the effect of such internal stresses. A few tests were carried out to determine the effect of scragging (*i.e.*, giving a permanent deflection by controlled overloading) on the fatigue resistance of spring plates.

The fatigue resistance of spring plates subjected to bending stresses can be improved by "temper-stressing," *i.e.*, quenching in water from the tempering temperature, and this improvement is considered to be due to the presence of compressive surface stresses which cause a reduction in the tensile stress on the tension side of the plates, particularly at the roots of surface irregularities. The scragging of springs is beneficial to their fatigue resistance, and this again appears to be due to residual compressive stresses in the tension surfaces.

#### Electrical Resistivity

Dr. Carl Benedicks (Metallografiska Institutet, Stockholm) presented a paper on "Electrical Resistivity of Faraday Steels; Gas Analysis and New Phenomenon on Remelting in Radiation Furnace." Electrical resistivity had been determined, using the Gallander principle, of eighteen small specimens from the material prepared by Faraday. The accuracy of the determinations on suitable specimens amounts to about  $\pm 1$  per cent. The effects of an insufficient thickness and surface of the specimen have been examined; the resulting errors scarcely exceed a few per cent. In three cases, where the resistivity had already been determined by other methods, the agreement was satisfactory. On the whole, the resistivities found agree fairly well with those calculated according to the author's formula, and somewhat better still when using individual coefficients for the different added elements in solid solution. It is noteworthy, however, that the steels containing gold show unexpectedly high resistivities, while the rhodium steels in one specimen yield a very high, and in the other, a very low resistivity. The influence of platinum, previously unknown, has been found to correspond to 1 atomic per cent. of platinum increasing the resistivity by 7 microhms per cm. per sq. cm.

One of the Faraday specimens was melted in the radiation furnace on two occasions, and the occluded gases were measured and analysed. In this connection a novel phenomenon, occurring with unilateral radiation, is described; sharp corners in a solid, bright specimen undergoing fusion

show a remarkable resistance to melting, and give rise to sharp protuberances, elongated in the direction of the radiation.

Another noteworthy phenomenon observed pertains to capillarity; on heating in a high vacuum, pure iron does not wet the crucible, while carbon steel does, this difference being due to a slight chemical reaction taking place in the latter case.

### Embrittlement at Elevated Temperatures

A paper by Mr. W. E. Goodrich, M.Met. (Sheffield) on "The Embrittlement of High-Tensile Alloy Steels at Elevated Temperatures" recorded the results of an investigation conducted on twenty-seven high-tensile alloy steels, to ascertain some of the factors influencing the embrittlement of these steels when subjected to a temperature of 450° C. Nickel-chromium, chromium-molybdenum, nickel-molybdenum, chromium-tungsten-molybdenum, and several types of nickel-chromium-molybdenum steels were included in a number of tests covering a period of 2,400 hr. Evidence was obtained on the effects of the presence of a maintained tensile stress during the soaking period; of fluctuations of temperature; and of initial heat treatment and variations in chemical composition. Strainage-embrittlement tests were also carried out at 200° C. and 450° C. on samples subjected to initial permanent tensile strains varying within the limits 0 to 5.0 per cent. Hardness and microstructural changes, resulting from the embrittlement treatments, were also examined.

As a result of the evidence obtained, it was considered that a mildly alloyed chromium-molybdenum steel was the most resistant to embrittlement; the use of the highest tempering temperature, consistent with the production of the required tensile strength, was an advantage; the presence of a maintained tensile stress of 11.0 tons per sq. in., or exposure to fluctuations of temperature below 450° C., had no influence on the ultimate embrittlement produced by soaking at that temperature; the amount of embrittlement was not sensibly influenced by the presence of initial permanent strain up to 5.0 per cent.; and that no changes in Brinell hardness or microstructure could be found to account for any embrittlement procured. The investigation was carried out at the request of the directors of the English Steel Corporation, Ltd.

### Surface Conditions and Fatigue Resistance

In their paper on "Further Experiments on the Effect of Surface Conditions on the Fatigue Resistance of Steels," Dr. G. A. Hankins, D.Sc., Dr. M. L. Becker, Ph.D., B.Met., and Mr. H. R. Mills, B.Sc. (National Physical Laboratory), described an investigation carried out as a continuation of previous work to determine the factors which cause the low fatigue resistance of unmachined steels, and to develop methods whereby the fatigue resistance can be improved. The first section of the paper gives the results of fatigue tests on two typical spring steels carried out to show the importance of surface irregularities of shape, both acting alone and in conjunction with surface decarburisation. The second section describes experimental attempts to improve the fatigue resistance of heat-treated steels by recarburising the decarburised surfaces produced during the manufacture of the steel. The third section gives the results of fatigue tests on unmachined steel forgings of over 100 tons per sq. in. tensile strength; and the fourth section gives the results of a few fatigue tests on unmachined rolled mild steel.

It is concluded that the combination of surface irregularities or inclusions with surface decarburisation is the major cause of the low fatigue resistance of unmachined spring steel plates.

Thus the combination of semi-circular surface grooves 1/9th mm. in radius, together with surface decarburisation, lowers the fatigue limit of a high-class silico-manganese steel from  $\pm 46$  tons per sq. in. to  $\pm 11$  tons per sq. in. Surface recarburisation of recarburised steels was found to increase the fatigue limit in some cases, but such treatment can hardly

be recommended for general commercial application. The effect of the unmachined surface on very high tensile forgings is very marked, the endurance fatigue limit being less than that of unmachined mild steel; it is concluded that it is most inadvisable for these very high tensile forgings to be subjected to fatigue stresses in service when the surfaces are in the as-forged heat-treated condition. It is also concluded that the effect of the unmachined surface on the fatigue strength of mild steel is not important, although exceptions can occur.

Mr. A. W. Hothersall (Research Department, Woolwich) and Mr. J. C. Prytherch (International Tin Research and Development Council) presented a paper on "A Study of the Origin of Porosity in the Tin Coating of Tinplate." Tinplate sheets of various grades were examined with a view to correlating the position of pores in the tin coating with visual imperfections or peculiarities of the tinplate. Pores were located by slight rusting in distilled water; their position was marked and the rust removed by a brief cathodic treatment in alkali; the tinplate was then examined microscopically. In finished tinplate, 30-50 per cent. of the pores in the coating were found in scratches produced in the final cleaning and polishing of the tinplate.

### Periodic Bands of Scruff

Microscopic examination of tinplate carrying less than 2 lb. of tin per basis box (22.4 g. per sq. m.) revealed the presence of periodic bands of scruff (crystals of iron-tin alloy embedded in the coating) running at right-angles to the direction of tinning. In tinplate withdrawn from the top of the grease-pot (*i.e.*, without passing through the cleaning or polishing rolls), pores in the tin coating were chiefly located in the scruff bands (41 per cent) and in the grease marks (34 per cent.). Scruff bands were not seen in tinplate carrying more than 3 lb. of tin per basis box (33.6 g. per sq. m.) but the largest grease marks of saucer-shape were grouped in periodic bands running at right-angles to the direction of tinning; practically all the pores not associated with scratches were located in these bands.

Discontinuities in the tin coating could be seen under the microscope at the site of the pores. Other discontinuities of similar appearance were also seen, a number of which could be made to respond to the hot-water test by lightly etching or stretching the tinplate. These discontinuities have been classified as potential pores. Only one-third to one-fifth of the total number of discontinuities or potential pores responded to the hot-water test.

The alloy layer remaining on tinplate after dissolution of the tin coating in a medium to which the alloy layer is practically inert was found to be highly porous; the porosity was considerably increased by slight stretching of the sheet. Coincidence of discontinuities in the tin coating and in the compound layer appears to be necessary for the existence of pores which respond to the recognised tests. The increase in the porosity of tinplate produced by slight deformation appears to be due to the increased porosity of the alloy layer, which raises the probability of such coincidence.

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EXCESSIVE burning of molten easily oxidisable alloys, particularly alloys containing 50 per cent. or more of aluminium to which elements reacting with air, including potassium, sodium, magnesium, lithium, calcium, barium, strontium, beryllium, phosphorus, arsenic, selenium, tellurium, may be added, is prevented by placing solid carbon dioxide on the surface of the melt; or the dry ice is so located without actually being placed on the bath surface that the heat causes an abundant evolution of gas covering the exposed alloy. Dry ice may be placed near mould openings prior to pouring the alloy. In making, *e.g.*, aluminium-magnesium alloy, the dry ice need only be employed just prior to the addition of magnesium. (See Specification 437,572, of Aluminium, Ltd.)

## A Valuable British Non-Ferrous Alloy

### Properties and Applications of "Everdur"

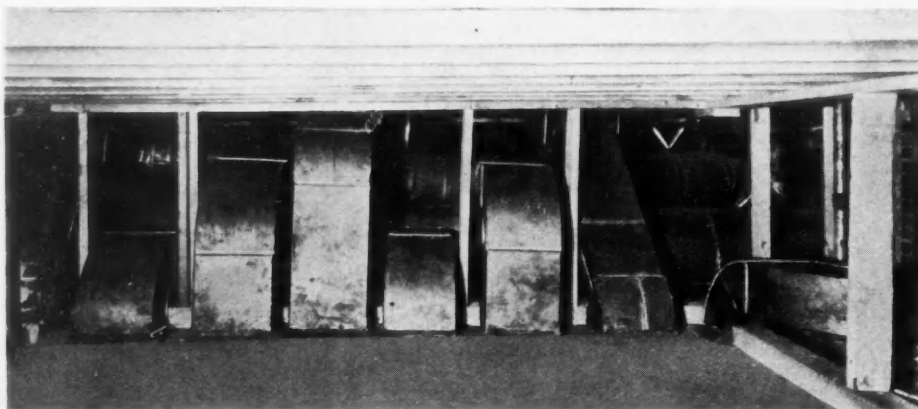
**A**N alloy of copper, silicon and manganese, whose remarkable properties have found it a wide application in the United States during the past 10 years, is now available as a British product, following the acquisition by I.C.I. Metals, Ltd., of the manufacturing and selling rights in the United Kingdom. Its registered trade mark, "Everdur," has also been assigned to the company for that territory, and the material is now produced in the form of plate, sheet, strip, tape, rod and wire over a wide range of sizes and tempers to suit individual requirements as well as in ingots for casting, properties, applications and methods of working being fully described in an illustrated booklet recently issued by the company.

"Everdur" is the first commercial application of copper containing substantial amounts of silicon, and marks a decided

advance in the metallurgy of copper alloys in that it combines the tensile strength of medium and low carbon steels with the non-rusting and corrosion-resisting properties of copper. The wide range of its potential applications may be judged from such other desirable properties as a high fatigue limit and good machinability, and from the fact that it is non-magnetic, easy to cast or to work hot or cold, and readily weldable by all commonly used methods. These properties should make possible the replacement of steel with "Everdur" in many applications involving corrosive conditions.

and pressure vessels, as well as in sewage disposal equipment, brewery equipment, fans and ducts for acid vapours, pickling crates, and non-magnetic covers and shields for electrical switchgear. One of its most important applications in its tube form is for oil and fuel piping on aeroplanes and in other situations where vibration is severe. "Everdur" wire has found a wide application for screens and filters for water works and sewage disposal works, whilst in the rod form it may be employed with advantage and economy for pump piston rods and low speed shafting.

Steel and copper have long been the standard materials for the construction of hot-water storage tanks. Each metal possesses its own distinct advantages; steel offers high strength and economical fabrication, but is subject to rust and corrosion which taint water and, in time, weaken the tank



This illustration shows the application of the new alloy "Everdur" in the construction of ducts for corrosive acids and vapours.

advance in the metallurgy of copper alloys in that it combines the tensile strength of medium and low carbon steels with the non-rusting and corrosion-resisting properties of copper. The wide range of its potential applications may be judged from such other desirable properties as a high fatigue limit and good machinability, and from the fact that it is non-magnetic, easy to cast or to work hot or cold, and readily weldable by all commonly used methods. These properties should make possible the replacement of steel with "Everdur" in many applications involving corrosive conditions.

Informative tables and graphical data showing its physical properties, and the results of actual physical tests on "Everdur," are given in the booklet. Among the most interesting of its physical properties are those at low temperatures, both strength and ductility increasing with the intensity of the cold, a fact which has been utilised in applications of the alloy for temperatures of  $-100^{\circ}\text{C}$ . and below. Its strength is also well maintained at temperatures up to  $250^{\circ}\text{C}$ ., and therefore for this range "Everdur" should be very satisfactory for structural purposes. Tests on resistance to fatigue by vibration have shown the alloy to be many times more resistant in this respect than annealed brass, copper and aluminium. Among the many chemicals and materials listed as those to which "Everdur" offers notable resistance to corrosion are acetic acid, alum solutions, beer, all strengths of brine (hot or cold), all strengths up to 50 per cent. caustic soda solutions, dry chlorine, corrosive, industrial and natural waters, sea-water, and cold tanning liquors.

The booklet referred to summarises many applications of "Everdur" in the various forms in which it is fabricated. Thus, in the form of hot or cold rolled plates, sheets, and strip, it is becoming widely used for hot water storage tanks

metal to a point below the limit of safety; copper is immune to rusting and highly resistant to other forms of corrosion, but, for some vessels of large capacity, frequently lacks sufficient strength. Long search for a material which would provide a balanced combination of the useful characteristics of both steel and copper has been rewarded with the development of "Everdur," which welds readily by gas and electric methods, and can be worked by the same processes and with similar equipment to that used for steel.

Fabricating costs for "Everdur" tanks are closely comparable with those of steel. "Everdur" tanks in service to-day range in size from small containers for petrol stoves to pressure vessels of 20,000 gal. capacity operating as units in chemical process work. "Everdur" tank plates have a tensile strength of from 24 to 29 tons per sq. in., depending on the thickness of the plate, an approximate yield point of from 9 to 14 tons per sq. in., and an elongation of from 30 per cent. to 40 per cent. in 8 in., properties which are comparable with normally accepted steel standards.

"Everdur" tanks, with their immunity to rust, provide the highest efficiency and most economic operation for underfired hot-water heaters. There can be no accumulation of rust at the bottom of the tank to insulate the water from the heating element. Such tanks have been subjected successfully to drastic tests before being placed in service. Two 10,000 gal. accumulator tanks, made of  $\frac{1}{2}$  in. shells and with heads of 0.65 and 0.75 in. in thickness, were each subjected to tests twenty-four hours' duration, under a constant hydrostatic pressure of 200 lb. per sq. in. No sign of leak or distortion could be detected during either test. "Everdur" fittings and connections for use with "Everdur" tanks are obtainable in the form of castings, hot stampings, drop forgings or drawn pressings.







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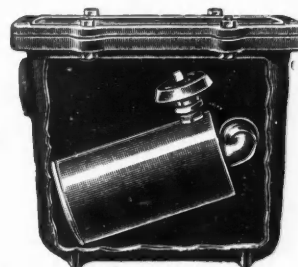
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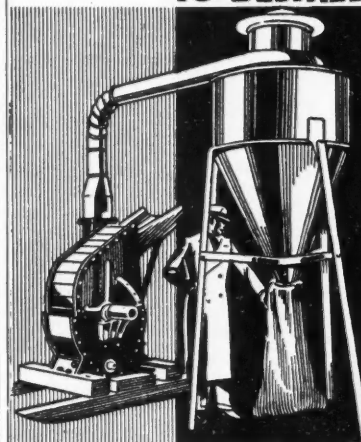
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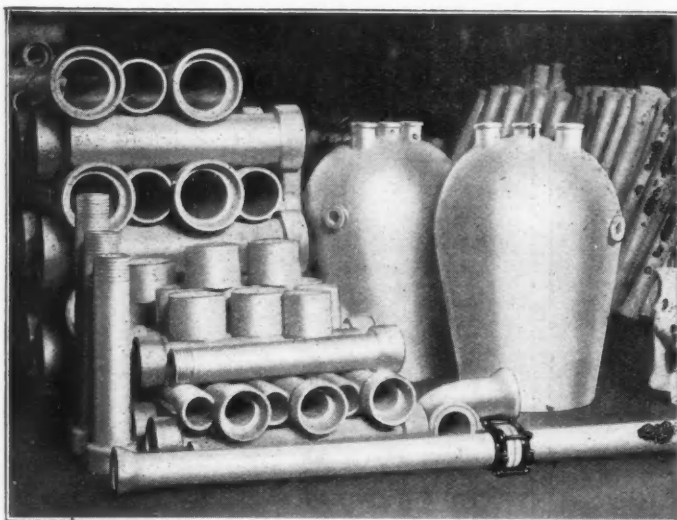
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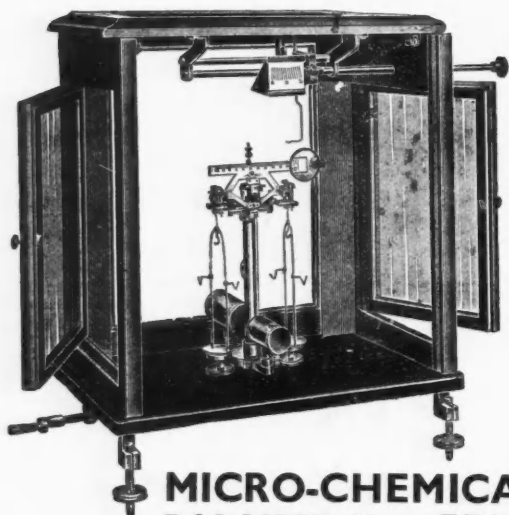


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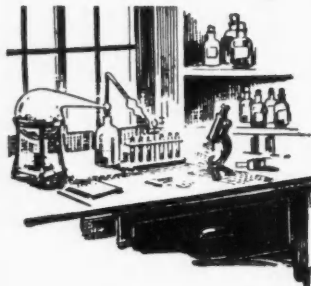
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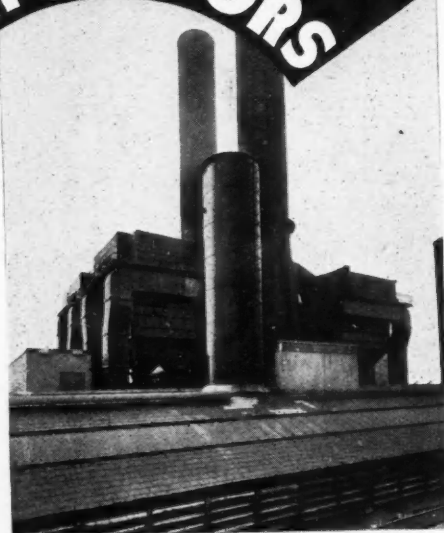
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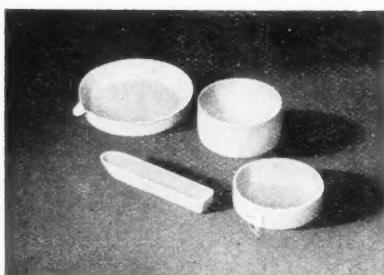
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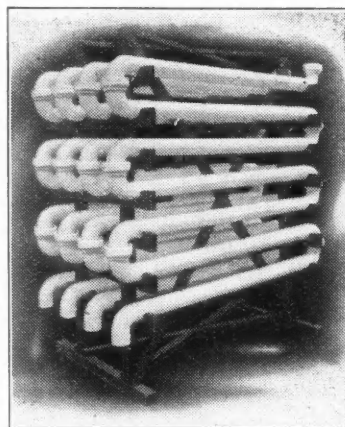
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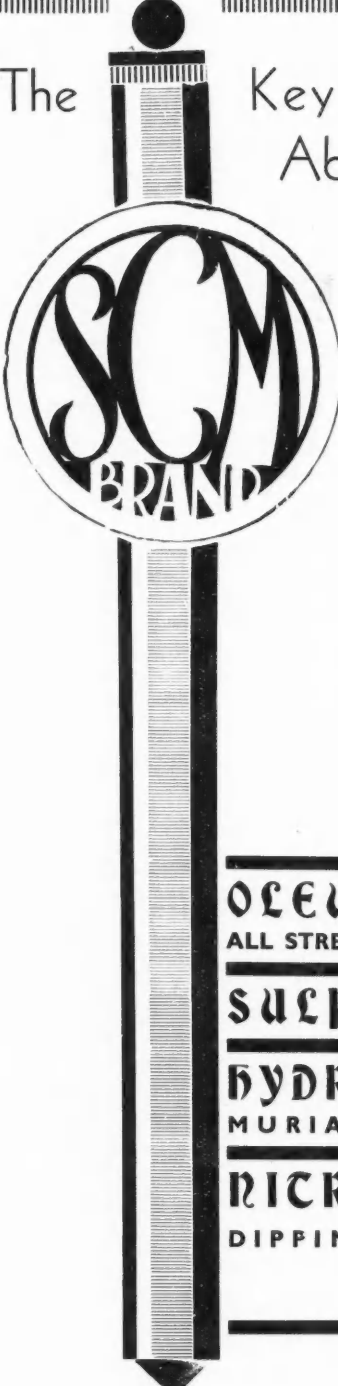
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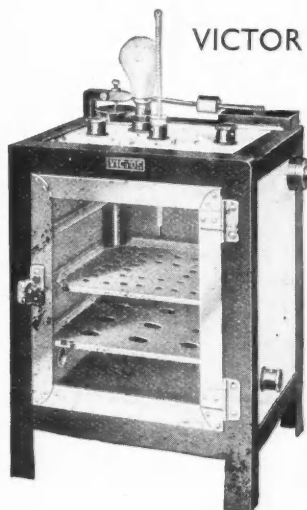
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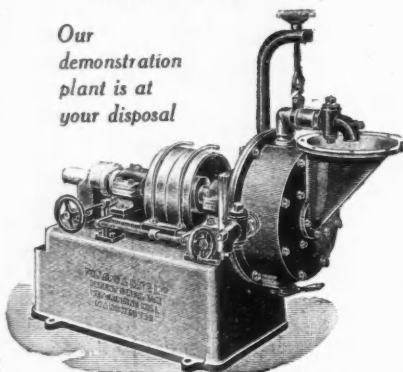
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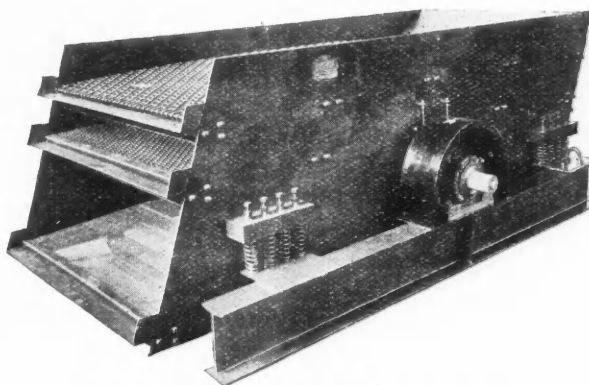
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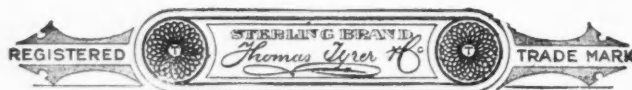
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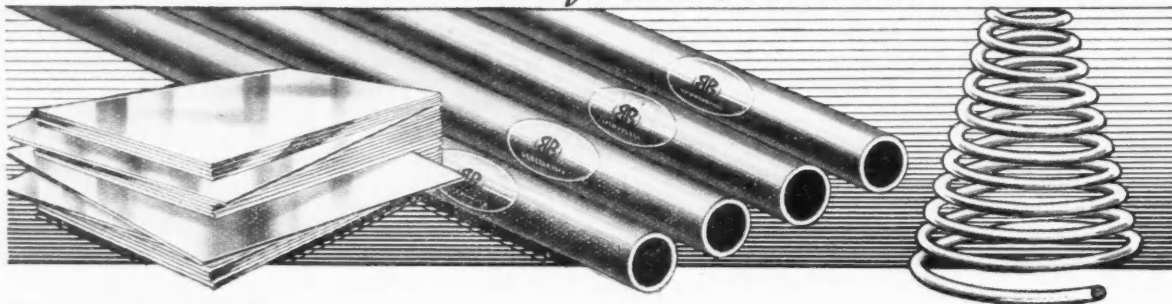
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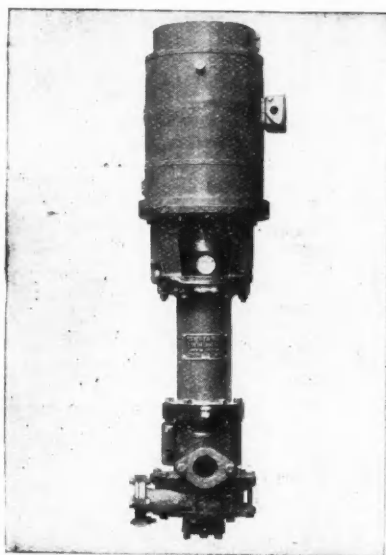
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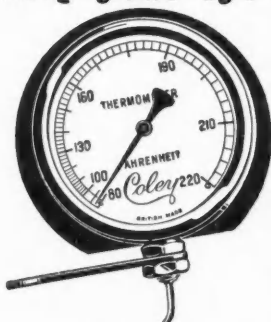
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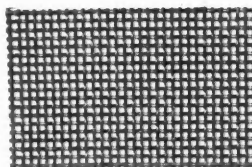
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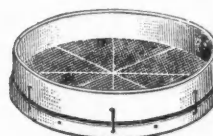
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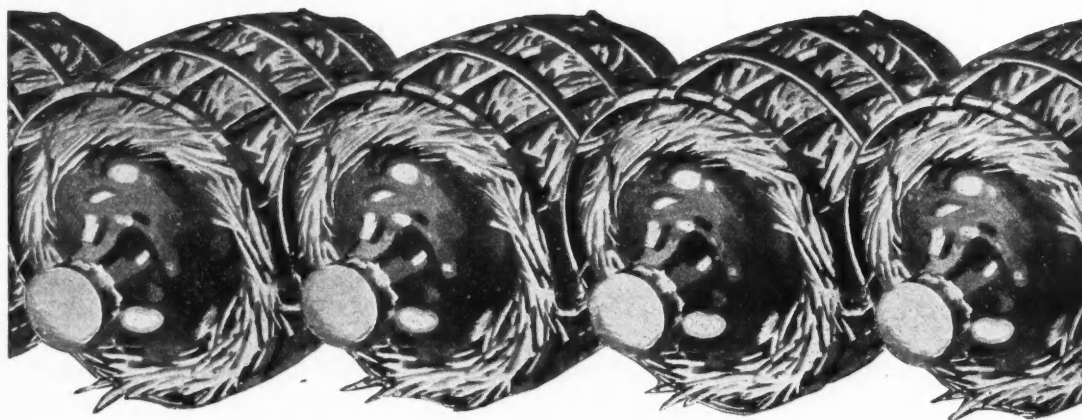
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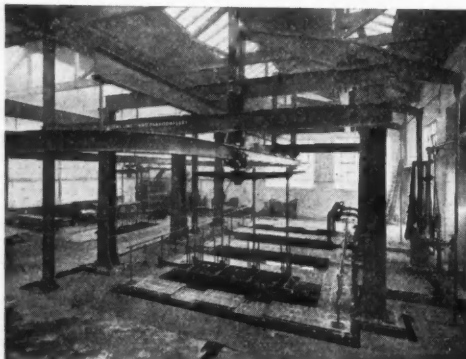
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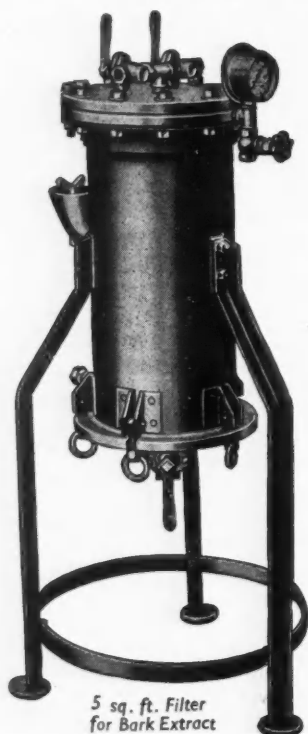
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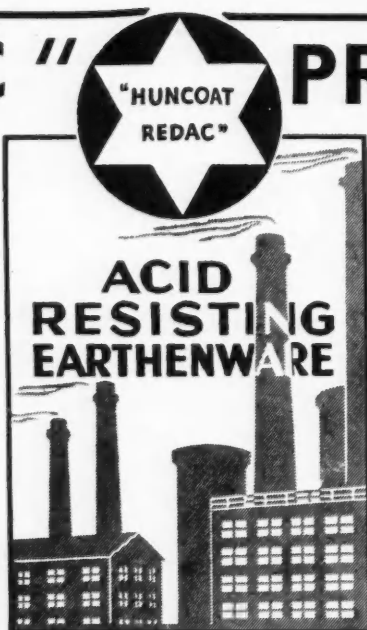
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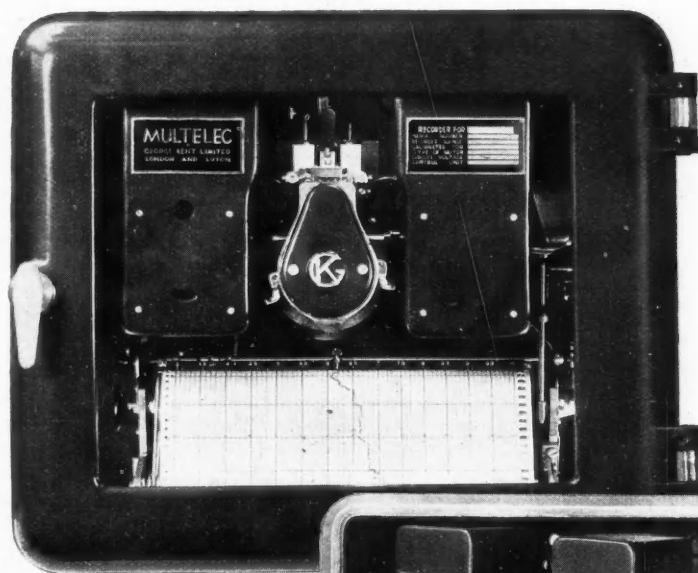
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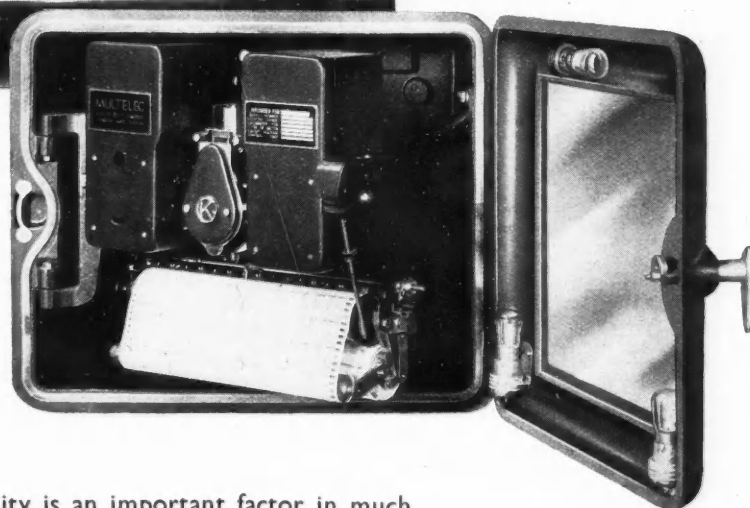
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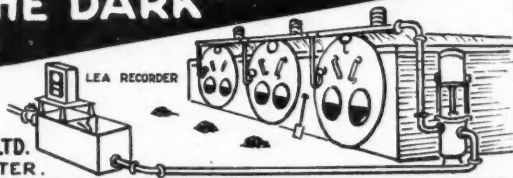
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